DOCTOR OF PHILOSOPHY

Policy experiments for the Saudi’s economy using a Computable General Equilibrium Model (CGE)

oil demand and tariff liberalisation effects on the Saudi economy

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Abdullah Al-Hawwas

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University of Dundee

Policy Experiments for the Saudi's Economy Using a Computable General Equilibrium Model (CGE): Oil Demand and Tariff Liberalisation Effects on the Saudi Economy

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Table of Contents

Table of Contents i

List of Tables..vii

List of Figures x

List of Mathematical Proofs xi

Acknowledgements xii

Declaration xiii

Certification...xiii

Abstract xiv

Chapter 1 1

Introduction..1

1.1 Introduction.. 1

1.2 Objective of the Study.. 4

1.3 Justification for adopting General Equilibrium over Partial Equilibrium Function 6

1.4 World Oil Demand and Supply 6

i. World Oil Demand 6

ii. World Oil Demand and Saudi Arabia's Role 8

iii. World Oil Supply 9

iv. Oil Demand Determines Oil Price Direction 11

v. Effect of Increase in World Oil Demand on Saudi Economy 14

1.5 Tariff Abolition Effects 17

i. International Trade Agreement: A Brief History.. 17

ii. Tariff Liberalisation and Developing Countries 18

iii. Saudi Arabian Accession to the World Trade Organisation (WTO)........... 20

1.6 Saudi Arabian Policy Taxation 21

Subsidizing policy... 23

1.7 Outline of the Study 24

1.8 Conclusion... 27

Chapter 2 28

The Saudi Arabian Economy 28

2.1 Gross Domestic Product (GDP)... 28

2.2 Private Sector Investment.. 39

2.3 Government Revenues and Expenditure 43

i. Government Revenues 43

ii. Government Expenditure 48

2.4 Oil market and Saudi Role 50

2.5 External Sector 54

2.5.1 Foreign Economic Relations 54

2.5.2 Imports 55

2.5.3 Exports 58

2.6 Labour Market 64

? Saudisation Strategy... 66

2.7 Conclusion.. 69

Chapter 3 71

Literature on Computable General Equilibrium (CGE) 71

3.1 Introduction.. 71

3.1.1 What is a Computable General Equilibrium Model (CGE)? 71

3.1.2 History of CGE Models 73

3.1.3 A Literature Survey of CGE Models.. 76

3.1.4 General Information about CGE Models 78

3.1.4.1 CGE Application to Oil Exogenous Shocks and Fiscal Policy............... 78

3.1.4.2 Advantages of CGE models 84

3.1.4.3 Policy Classification of CGE Models 86

Policy Classification:.. 86

3.1.5 Conclusion.. 89

Chapter 4 91

Social Accounting Matrix (SAM)..91

4.1 Introduction.. 91

4.2 What is a SAM? 91

4.3 Difference between SAM and Input-Output (IO) 94

4.4 Social Accounting Matrix for Saudi Arabia... 95

4.4.1 Disaggregate SAM for Saudi Arabia 96

4.4.2 New Disaggregate SAM 2000 for Saudi Arabia.. 97

4.5 Conclusion.. 107

Chapter 5 108

Model and Methodology 108

5.1 CGE Model for Saudi Arabia... 108

5.1.1 Justifications for Adopting Lofgren et al. (2002) CGE Model..................... 108

5.1.2 Standard Structure of CGE Model 109

5.1.3 Equations of the Model.. 115

5.1.4 Justification for Adopting Cobb-Douglas Function.................................... 115

5.1.5. Household Welfare Measures 132

5.1.6 Closure Rule... 133

5.1.7 Calibration.. 135

of calibrating parameters are presented in Appendix 1. 137

5.2 Conclusion.. 138

Chapter 6 140

Simulation Results.. 140

6.1 First Experiment.. 140

6.1.1 First Simulation (SIM-1) 140

i. Macroeconomic Effects of Increase Oil Demand by 5%........................... 140

ii. Effect on Prices and Volumes of Commodities 140

iii. Factor Market Effects 145

iv. Households Income and Consumption Effects 146

v. Household Welfare Effects 147

6.1.2 Second Simulation (SIM-2).. 148

i. Macroeconomic Effects of Increase World Oil Demand by 5% 148

i. Effect on Prices and Volumes of Commodities... 150

iii. Factor Market Effects 152

ii. Households Income and Consumption Effects 153

iii. Household Welfare Effects.. 153

role in CGE models base on the assumptions of closure rule in a particular experiment. 154

6.1.3 Note about results of SIM-1 and SIM2:.......... 154

6.1.4 Conclusion.......... 155

6.2 Second Experiment 157

6.2.1 The Model Closure Rule 157

6.2.2 Justification carrying out Experiment two 158

6.2.3 First Simulation (SIM-1):.......... 160

i. Macroeconomic Effects of Tariff Abolition 161

ii. Effect on Prices and Volumes of Commodities 163

iii. Factor Market Effects 166

iii. Households Income and Consumption Effects 167

iv. Household Welfare Effects.......... 168

6.2.4 Second Simulation (SIM-2).......... 170

i. Macroeconomic Effects of Tariff Abolition with Applying Sales Tax 170

ii. Prices and Volumes of Commodities Effects 172

iii. Effects on Factor Market 174

iv. Households Income and Consumption Effects 175

v. Household Welfare Effects.......... 176

progress amount of 5.85%, while non-Saudi household worse off by -1.40% due to the decline in expenditure and consumption (-1.08% and -1.40 respectively). 178

vi. Note about the simulation results:.......... 178

6.2.5 Third Simulation (SIM-3) 179
i. Macroeconomic Effects of Tariff Abolition 179
ii. Effect on Prices and Volumes of Commodities 181
iii. Factor Market Effects 183
iv. Household Income and Consumption Effects 184
v. Households Welfare Effects 186
vi. Note on the simulation result of SIM-3 187
6.3 Sensitivity Analysis 188
6.3.1 Sensitivity Analysis in case full employment 188
6.3.2 Sensitivity Analysis in Case Unemployment 190
6.4 Conclusion 192
Chapter 7 194
Conclusions and suggestions for future research 194
7.1 Conclusions 194
? Summary of Results 196
7.2 Some limitations and suggestions for future research 200
Appendixes 203
Appendix 1 203
Calibration Parameters 203
Appendix 2 204
Derivation 204
i. Derivation of Equation (32) and (33). 204
ii. Derivation of Equation (54)and (55) [EV and CV] 205

iii. Derivation of Factor Demand Function 206

iv. Derivation of Import-Domestic Demand Ratio 207

v. Derivation of Export-Domestic Supply Ratio 208

Appendix 3: 210

Saudi Model Equations, Variables, Sets and Parameters 210

i. List of Saudi Model Equations 210

ii. Endogenous Variables and Description 213

iv. Sets and Sub-Sets Table 216

iv. Exogenous Variables and Notations 217

v. Parameters 218

Appendix 4 219

GAMS Codes 219

Appendix 5 247

Disaggregate Social Accounting Matrix 2000 for Saudi Arabia, (SR million) 247

Reference 251

List of Tables

Table 2. 1 GDP Growth and Oil Price US $/barrel 29

Table 2.2 Gross Domestic Products by Sector at Constant Price 1999, (SR Million) ... 31

Table 2.3 Growth of GDP, GDP-Oil and GDP Non-Oil Sectors 34

Table 2.4 Share of Oil GDP and Non-Oil GDP in Total GDP 37

Table 2.5 Government Total Revenue and Expenditure (SR Million) 46

Table 2.6 Exports Structure at Beginning and End of Strategy Period 47

Table 2.7 Growth of Imports, Export and Oil Share in Total Exports (Nominal value,SR Million) 57

Table 2.8 Top Ten Country Imports (SR Million) 61

Table 2.9 Structure of Imports 62

Table 2.10 Export by Nature of Item (SR Million).. 63

Table 2. 11 Unemployees Rate By Sex and Nationality (1999 - 2008) 69

Table 4. 1 Economic Structure for Saudi Arabia in 2000 as Percentage of Total (%) 100

Table 4. 2 Sectoral Classification of 2000 SAM and Less Disaggregate2000 SAM of Saudi Arabia.. 102

Table 5.1 Elasticity Values of CES and CET Functions... 137

Table 6.1 Macroeconomic Effects of Increase Oil Demand by 5% (SIM-1)............... 141

Table 6.2 Price and Volume Effects of Increase World Oil Demand by 5%, (SIM-1) 143

Table 6.3 Factor Market Effects (SIM-1).. 146

Table 6.4 Household Income and Consumption Effects... 148

Table 6.5 Macroeconomic Effects of Increase World Oil Demand by 5%, (SIM-2) .. 149

Table 6.6 Price and Volume Effects of Increase World Oil Demand by 5%, (SIM-1) 151

Table 6.7 Factor Markets Effects, (SIM-1)... 153

Table 6.8 Household Income and Consumption Effects, (SIM-1)............................... 154

Table 6. 9 Saudi Arabian Corporation Tax Rate.. 24

Table 6.10 Saudi Arabian Income Tax Rate.. 24

Table 6.11 Macroeconomic Effects of Tariff Abolition without Compensation, (SIM-1) 162

Table 6.12 Price and Volume Effects of Tariff Abolition without Tariffs Compensation 165

Table 6.13 Factor Market Effects without Tariff Compensation, (SIM-1) 167

Table 6.14 Household Income and Consumption Effects of Tariff Abolition............ 168

Table 6.15 Consumption Effects of Tariffs Abolition across Sectors without Tariff Compensation, (SIM-1) 169

Table 6.16 Macroeconomic Effects of Tariff Abolition and Imposition Sales Tax, (SIM-2)... 171

Table 6. 17 Price and Volume Effects of Tariff Abolition and Imposition Sales Tax, (SIM-2)... 173

Table 6.18 Factor Markets Effects of Tariffs Abolition and Imposition Sales Tax, (SIM-2)... 175

Table 6. 19 Household Income and consumption Effects of Tariffs Abolition and Imposition Sales Tax, (SIM-2).. 177

Table 6. 20 Household Consumption Effects across Sectors and Sales Tax Compensation SIM-2 177

Table 6.21 Macroeconomic Effects of Tariff Abolition and Direct Tax Compensation, (SIM-3)... 180

Table 6. 22 Price and Volume Effects of Tariff Abolition and Imposition Direct Tax, (SIM-3)... 182

Table 6. 23 Factor Market Effects of Tariff Abolition and Imposition Direct Tax, (SIM-3).. 184

Table 6.24 Household Income and Consumption Effects of Tariff Abolition and Imposition Direct Tax, (SIM-3) 186

Table 6.25 Household Consumption across Sectors Effects of Tariff Abolition and Imposition Direct Tax, (SIM-3) 187

Table 6. 26 Household Consumption across Sectors Effects of Tariff Abolition and Imposition Direct Tax, (SIM-3) 189

Table 7. 1 First Experiment: Increase Oil Demand by 5% 197

Table 7. 2 Relationship of World oil Demand, Oil Prices and Saudi GDP 197

Table 7. 3 Second Experiment: Tariff Elimination Results 199

List of Figures

Figure 2.1 GDP Growth Rate and Oil Price.. 41

Figure 2.2 Growth of Oil GDP and Non-Oil GDP 41

Figure 2.3 Non-Oil Share in Total GDP 42

Figure 2.4 Oil and Non-Oil Revenue 43

Figure 2.5 Oil Share to Total Revenue.. 47

Figure 2.6 Government Total Revenue and Expenditure... 48

Figure 2.7 Growth of Imports and Exports 60

Figure 2.8 Crude Oil Share in Total Exports 61

Figure 5.1 Production Technology ……………………….………………… …….95

Figure 5.2 Flow of Marketed Commodities…..……………………...… …………….96

Figure 5.3 Commodities Flow Chart outlining Calibration Procedures for the Saudi SAM 139

Figure 6.1 Co-Movement between Oil Demand and Oil Price 13

Figure 6.2 Shifts in Oil Demand and Oil Price 16

Figure 6.3 Macroeconomic Effects of Increase World Oil Demand by 5%, (SIM-1). 142

Figure 6.4 Macroeconomic Effects of Increase World Oil Demand by 5%, (SIM-2). 149

Figure 6. 5 Macroeconomic Effects of Tariff Abolition without Compensation, (SIM-1) 162

Figure 6.6 Macroeconomic Effects of Tariff Abolition and Imposition Sales Tax, (SIM-2).. 171

Figure 6.7 Macroeconomic effects of Tariff Abolition and Direct Tax Compensation, (SIM-3).. 180

Figure 6.8 Sensitivity Analysis: Doubling and Halving Parameter (CES) Values with Elimination Tariff (SIM-1).. 189

List of Mathematical Proofs

i. Price Elasticity of Oil Export Demand…………………………........……204

ii. Derivation of Compensation and Equivalent Variation ……….……….….…205

iii. Derivation of Factor Demand…………………………………….………206

iv. Derivation of Import-domestic Demand Ratio ……………….……..……207

v. Derivation of Export-domestic Demand Ratio…………………… ..…….208

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Declaration

I hereby declare that I am the author of this thesis and that I have consulted all the references cited. All the work, of which this thesis is a record, has been done by myself and has not been previously used for a higher degree.

Signed ……………….
Abdullah I. Al-Hawwas, PhD Candidate
Date…………………..

Certification

This is to certify that Mr. Abdullah I. Al-Hawwas conducted his research under my supervision in the Department of Economic Studies, University of Dundee. Mr. Al-Hawwas has fulfilled all the conditions of the relevant Ordinances and Regulations of the University of Dundee for obtaining the Degree of Doctor of Philosophy.

Signed ………………
John Dewhurst, Supervisor
(Professor of Economics)
Date…………………

Abstract

This thesis aims to provide a comprehensive analysis using a Computable General Equilibrium (CGE) Model for the economy of Saudi Arabia and of the possible effects of some policy measures. It further explains the mechanisms through which they affect different economic agents. Using a static CGE Model, we show the possible micro and macroeconomic effects of an exogenous shock of world oil demand and the possibility of adapting a trade liberalisation regime in Saudi Arabia. Specifically, this study comprises of two main experiments each with a number of simulations.

The first experiment examines the effects of an increase in world oil demand on the Saudi economy. Due to the significant effects of closure rules on the results, this experiment implements two simulations based on an alternative closure rules, the first in which saving is flexible and investment remains fixed, the second in which investment is flexible and saving remain fixed. The second experiment investigates the impact of tariff elimination on the Saudi economy. As a result of dropping the import tax, government revenue declines. Based on that the experiment includes three simulations: (i) Examines the effects of tariff elimination without revenue neutral policies, (ii) examines the effects of tariff elimination combined with revenue neutral policy (sales tax) and (iii) examines the effects of tariff elimination combined with income tax.

Sensitivity analysis has been done to test the robustness of the model. Household welfare effects have also been measured across households using an Equivalent Variation measure (EV). The study concludes that the third simulation (iii) in the second experiment is preferred in case compensation tariff drop but the first simulation (i) in second experiment is better and use oil revenue for compensation instead.

Chapter 1
Introduction

1.1 Introduction

Saudi Arabia is the largest Arab country of the Middle East, it occupies about 80 percent of the Arabian Peninsula with a total area of 2,217,949 km^2. Saudi Arabia's population is 27,136,977 including 8.4 million resident foreigners, General Census of Population and Housing (2010).

Before the discovery of oil, Saudi Arabia was one of the poor countries in the region, depending essentially on subsistence agriculture and trade activities which took place during the pilgrimage to the Holy Land. This situation has changed after oil was discovered in 1938. Today the economy is dominated by the production and export of oil. Oil export revenues have accounted for around 90% of total Saudi export earnings and state revenues and above 40% of the country's gross domestic product (GDP), (EIA, 2009). Globally Saudi Arabia plays a crucial role in the crude oil market because it is the leading exporter of crude oil in the world. It's total proven oil reserves stands at 264.3 billion barrels (CIA Fact Book, 2008) and is ranked number one in the world. Similarly, it is the leading oil exporter in the world with an estimated 8.2 million bbl/d of crude oil and is ranked second in the production of crude oil at 9.2 million bbl/d (CIA Fact Book, 2009). According to the Oil and Gas Journal, Saudi Arabia has proven natural gas reserves estimated at 258 trillion cubic feet (Tcf), the fourth largest in the world behind Russia, Iran, and Qatar. Over 5 Tcf was added in 2008, and over the last decade and a half, Saudi ARAMCO, the state oil company, has added about 75 Tcf of non-associated reserves (EIA,2009).

The economic structure of Saudi Arabia is unique among developing oil-export based economies. Oil is the main source of income for the government, who is also the owner of all the natural resources. Saudi Arabia's hydrocarbon sector operations are dominated by the state-owned oil company, Saudi ARAMCO, the world's largest oil company in terms of proven reserves and production of hydrocarbons. Thus, the government obtains most of its expenditure revenue from the oil exports via Saudi ARAMCO.

Theoretically, the increase in oil revenues that occur from governmental sale of oil potentially increases the level of governmental domestic spending, which is the way in which oil revenues are transferred from the government to the domestic economy. In addition, the government owns most of the public services (electricity, drinking water, communication, transportation, etc.) and owns the lion's share of the large production companies, primary petro-chemical processing and manufacturing. The government is also the dominant employer of local labour. There are almost no taxes imposed on either sales or income.

There was a tremendous increase in world demand for oil as a result of the continued prosperity of the industrialised nations and the fast growing economies of developing countries. In 1970s there was a sudden increase in world oil prices that was primarily a result of two political events imposed upon the region: the Arab–Israeli War of 1973-74 and the Iranian Revolution in 1979. Subsequently, oil revenues of the Arab oil producing countries rose sharply.

As with many primary commodities, the demand for oil is highly price inelastic, such that minor demand-supply shifts lead to major changes in prices and the exporting nations' revenues. The variability of export earnings weighs most heavily on the small economies which specialise in primary commodities production. The speed and extent of adjustment to the price shocks vary from nation to nation and some economies may take a considerably longer time to adjust.

In common with other primary commodities sectors the Saudi oil sector is essentially an enclave sector. Most of the output is sold in foreign markets and most of its inputs are bought from these markets and have limited linkages with the rest of economy. Due to these limited linkages, oil prices impact on the economy primarily through their effect on oil revenues, which in the Saudi case, accrue entirely to the State. Since the government budgets have trended to entail large imbalances (surpluses and then deficits), the government sought to moderate the impact on the economy of the oil shocks. In the process, large financial reserves were accumulated during the period of rising oil prices (1972-1980), which were drawn upon in the subsequent periods of falling (1981-1986) then fluctuating oil prices. As an additional step, in order to ensure a long–term economic stability, the government invested heavily in the diversification of the production bases of the economy and more particularly in the development of modern manufacturing industries.

Trade liberalisation on the other hand was one of the major economic reform programs implemented in the last two decades. The program was pursued in various phases incorporating policies of tariff reduction, simplification of tariff structure, and the "tariffication" of quantitative restrictions. Some of these reforms were pursued unilaterally, while others were done under various multilateral agreements such as those with the World Trade Organisation (WTO). The accession to the WTO is among the most important policy changes that a country may undertake. Saudi Arabia became the 149th member of the WTO in 2005. The benefits and challenges that the country faced as a result of accession to the WTO called for urgent economic reforms to mitigate the impact of trade reforms implemented by the WTO on the Saudi economy.

Trade liberalisation, particularly tariff reduction affects relative price that triggers changes in both sectoral price ratios and domestic foreign price ratios. These changes in turn result in reallocation of production and resources, which could lead to contraction in some production sectors and expansion in others.

Furthermore, it generates a net of direct and indirect changes that makes it extremely difficult to trace down the effects on various households. To be able to gain a better understanding of the effects the analysis may therefore require an economy-wide model. A CGE model serves to examine these effects properly.

1.2 Objective of the Study

The main objective of this study is to investigate two major issues: First, an impact of macroeconomic fluctuations as a result of changes in the world demand for crude oil in the Saudi economy. Second, examine the role of fiscal policy as a result of accession the WTO on the Saudi economy. This is an important area to study as membership in the WTO requires the abolition of some tariffs which could impact Saudi Arabian revenue sources.

Although the Saudi economy is vulnerable to external shocks because of its heavy reliance on oil, there is a shortage of empirical studies devoted to explaining the effect of changes in the global demand for oil. This study provides a sound motivation on the importance of oil demand shocks on oil-based economies and macro and micro effects of fiscal policy.

The identification of key sources that will generate exogenous shocks and policy changes that have significant effects on the Saudi economy is very important for policymakers because it provides a mechanism for various policies that Saudi Arabia can adopt to regulate the economy.

The main research questions of this study are:

1. To what extent is the Saudi economy vulnerable to external shocks? In particular what is the impact of increasing world demand for oil on the Saudi economy?
2. What would be the impact of policy changes on the Saudi economy as a result of the abolition of tariffs?

To answer these questions, a static Computable General Equilibrium (CGE) model is built to analyse the micro and macro economic impact of exogenous shocks and policy changes on output, aggregate exports, aggregate imports, government expenditure, private consumption, labour market and welfare of households.

The model is numerically implemented using a data social accounting matrix (SAM) of the Saudi Arabian economy with base year 2000. The SAM contains information on input-output linkages across 8 sectors. There are three production factors and two types of households. Capital is treated as a sector specific factor, while labour is assumed freely mobile between industries for Saudi labour but immobile for non-Saudi labour.

1.3 Justification for adopting General Equilibrium over Partial Equilibrium Function

There are two ways to estimate the economic effects of policies: partial equilibrium and general equilibrium analysis. Partial equilibrium analysis examines the effects on agents in the market or markets directly affected by the proposed policy, assuming all else remains constant. Partial equilibrium analysis is concerned with the direct effects as well as any ripple effects through the economy as a result of the direct effects, i.e, not holding all else constant. While giving a good indication of the preliminary effects of a proposed policy, being easy to use and having a relatively low cost, partial equilibrium analysis, by itself, is incomplete. However, partial equilibrium does not take into account the feedback effects policies may have on the other sectors of the economy. In order to better take these into account, a general equilibrium approach is more appropriate. Thus the development of computable general equilibrium (CGE) models for policy analysis allows us to evaluate outcomes more effectively with numerical estimates.

1.4 World Oil Demand and Supply

i. World Oil Demand

Oil has a unique position in the world's economic system. It is a vital source of energy, an irreplaceable transport fuel, and an essential raw material in many manufacturing processes. The world oil consumption[1] amount to 85.5 million barrels per day in 2008 and was forecasted by the Energy Informatio n Administration (EIA) to increase by a total of 27.3 million barrels per day to 112.8 million barrels per day in

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[1] http://www.eia.doe.gov/emeu/international/oilconsumption.html
EIA ,2009.

2020 (EIA, 2009).

The demand for oil in China and India has dramatically increased in recent years, today China the country with a population exceeding 1.3 billion and economic growth of 9.5 per cent over the past three years, is the second largest consumer of oil in the world at rate of 7.6 million barrels per day in 2007 (EIA). With its increasing oil consumption, China today plays a major role on the international oil markets, and a change in its consumption could seriously disrupts these markets. Moreover, today China occupies a dominant place on the international scene and a large drop in its economic activity could significantly affect world growth.

Hamilton (2009) implies that while China had been growing at a remarkable rate for a quarter century, it has only recently become big enough (relative to the global economy) to make a material difference. He gives an example, the 4.9% world GDP average annual growth rate over 2003-2007 compares with a 2.9% average over 1990s. With regard to China's total petroleum production and consumption, it was a net exporter of petroleum up until 1992 when its imports were only up to 800,000 barrels/day in 1998. By 2007 China's net imports were estimated to be 3.6 million barrels per day, making it the world's third biggest importer and a dominant factor in current world energy markets.

In his study, Fredriksen (2006) indicates that China's energy consumption will continue to grow. According to the latest figure from the Energy Information Administration (EIA, 2006) China's oil consumption will grow at average of 3.8 percent a year between 2003 and 2030. By 2030 oil consumption will reach approximately 15 million barrels per day, which means that in 2030 China's oil consumption will account for about 13% of world's oil demand compare to 7% in 2003.

However, India is another example an important economy in terms of oil demand. Ghosh (2008) points out that oil in India is the second largest source of primary commercial energy in after coal. India is a net importer of energy, with more than 70% of its energy requirements composed of crude oil. Importation of crude oil has gone up from 85.62 million barrel (mb) in 1970–1971 to 803 mb in 2006–07. According to International Energy Agency (IEA), India's projected demand for crude oil in 2031–2032 will be in the range of 2,555-3,548 mb. Assuming domestic production will be at 256 mb, the range of import dependence of crude oil for India will be 90% to 93% in 2031–2032. The United States, on the other hand, as Monfort suggested (2008)[2], continued unchallenged as the world's single largest oil-consuming nation in 2007, using almost one fourth of the global total at a rate of 20.7 million barrels daily. The industrialised countries are the largest consumers of oil. The countries of the Organisation for Economic Cooperation and Development (OECD) for instance, account for almost 2/3 of worldwide daily oil consumption. In 2007 the demand for oil by OECD accounted for 49.8 million barrels per day (EIA, 2009).

ii. World Oil Demand and Saudi Arabia's Role

Saudi Arabia has a vital role in meeting world petroleum needs because of its huge oil reserves, productive capacity and the flexibility to increase or decrease oil production. Henderson (2008) points out that Saudi Arabia effectively heads OPEC because it is the largest oil producer and has the greatest volume of exports, the biggest reserves, and most crucially, extra unused capacity to produce and export. At the same

[2] [2] http://www.worldwatch.org/node/5666#notes

time, Saudi Arabia can afford a substantial drop in production because it maintains a cautious government-spending program. This enables Saudi Arabia to become a swing producer that can either shift up or scale down output to affect world oil prices. Indeed, Saudi Arabian exports represented 16.3% of total world crude oil demand in 2006 (IMF) and according to the Oil and Gas Journal, Saudi Arabia contains approximately 264 billion barrels of proven oil reserves. On the other hand, Hamilton (2009) points out:

> *"Because the Saudi's had historically used their excess capacity to mitigate the effects of short-run supply shortfalls, many analysts had assumed that they would continue to do the same in response to the longer run pressure of growing world demand, and most, forecasts called for continuing increases in Saudi production levels over time".* p.10

Alhajji and Huettner (2000) suggest that Saudi Arabia is a dominant firm. The dominant firm has control over world oil prices but not its competitors'. This result is consistent with the statement "Saudi Arabia is unique in its ability to swing production over a wide range and thereby affect the world price." (Rown and Weyant, 1981).

iii. World Oil Supply

Outlook of world oil supply has been projected by OPEC (2006). The following discussion summarises projection results of oil supply by OPEC and non-OPEC, countries between 2005 and 2025.

a) Non-OPEC Oil Supply

The study points out that over recent years non-OPEC production has been confronted with a series of challenges, including the period of low oil prices in 1998–99. Yet despite this during the five-year period –2000–05– the annual growth of non-OPEC production averaged close to 0.9 million barrel/day (mb/d). However, non-OPEC supply is expected to continue to expand during this decade and beyond. Annual growth is expected to average in the range of 1.2 and 1.4 mb/d over 2006–08 and more than 0.9 mb/d in 2009–10. Over the period 2005–10, represents a cumulative increase of close to 6 mb/d. Regionally, Russia and the Caspian region will lead non-OPEC growth, with the bulk of the increase expected to come from the Caspian. Outside these regions supply growth is driven primarily by increases in offshore West Africa, offshore Latin America, and non-conventional sources in North America. The Middle East, OECD Asia and other parts of Asia will show modest gains, whilst Western Europe expect a decline driven by a fall in output fom the North. This assessment is based on expected trends of producing fields by country, including over 300 new developments. However, more projects are likely to emerge in the years ahead.

Looking at non-OPEC supply in the medium-term, Russia and the Caspian region will continue to represent the most promising future for non- OPEC production growth. Overall supply is expected to rise to 58–59 mb/d in the post-2015 period and remain near this level to 2025.

b) OPEC Oil Supply

The study also illustrates that in recent years OPEC production has risen to the highest level in over twenty years in response to strong oil demand growth, as well as the temporary slow-down in the rate of increase of non-OPEC supply. In addition OPEC crude capacity has continued to increase.

Spare capacity in OPEC Member Countries in 2005 was around 2 mb/d, sufficient to ensure the market was at all times well supplied. In line with OPEC's longstanding commitment to supporting oil market stability, further OPEC crude capacity expansion plans over the medium-term are expected to result in almost 38 mb/d crude capacity by the end of 2010, representing an increase of nearly 5 mb/d from end-2005. Similarly, production capacity of Natural Gas Liquids (NGL) and other liquids will be expanded almost 2 mb/d to reach 6 mb/d by 2010.

OPEC capacity expansion plans, therefore, give rise to the expectation that significant increases in spare capacity will occur over the medium-term. Indeed, OPEC spare capacity rising to 5–8 mb/d over this timeframe. However, worldwide reservation has increased from just 0.6 trillion barrel in the 1940s, to 2 trillion barrel in the 1970s, up to the most recent mean in the range of 3.3 to 3.9 trillion barrel.

Most studies conclude that two-thirds of the conventional resources lie in OPEC member countries. These expected developments demonstrate the contribution that OPEC continues to make in providing a firm foundation for future market stability. There remains a significant amount to be found, with the bulk lying in the Middle East, Russia, South America. Geological Survey (USGS) estimates that as much as 25 per cent (900 billion barrels) of the total identified liquid resources outside the US remain undiscovered OPEC (2006).

iv. Oil Demand Determines Oil Price Direction

While oil markets may behave like other commodity markets much of the time, the oil market has unique features: First, few commodity markets have an institution like the Organisation of Petroleum Exporting Countries (OPEC). Since its creation in 1960 OPEC has had a variable influence on the price of oil through its member nation quota system. Second, oil has been subject to supply disruption due to political instability as well as technical factors. Third, psychological or expectations effects, tied to real or perceived probabilities of market disruption, may lead to price volatility. Finally, world oil transactions are settled in U.S. dollars, which affects the value of the dollar in world currency markets, as well as the magnitude of international reserves held by petroleum importing and exporting nations around the world. (Pirog 2005).

Perry (2008), reports that an increase in global demand for oil has been responsible for the increase in global oil prices. He also indicates that global GDP growth and oil production move in the same direction and concludes that since 2002 world GDP increased by about 30% and world oil production increased by about 12%. Recent studies by Krichene (2002), Cooper (2003), Dees et al. (2007) suggest that oil demand is highly price–inelastic. This has policy implications in net importing countries which have to depend on prices determined by the exporting countries.

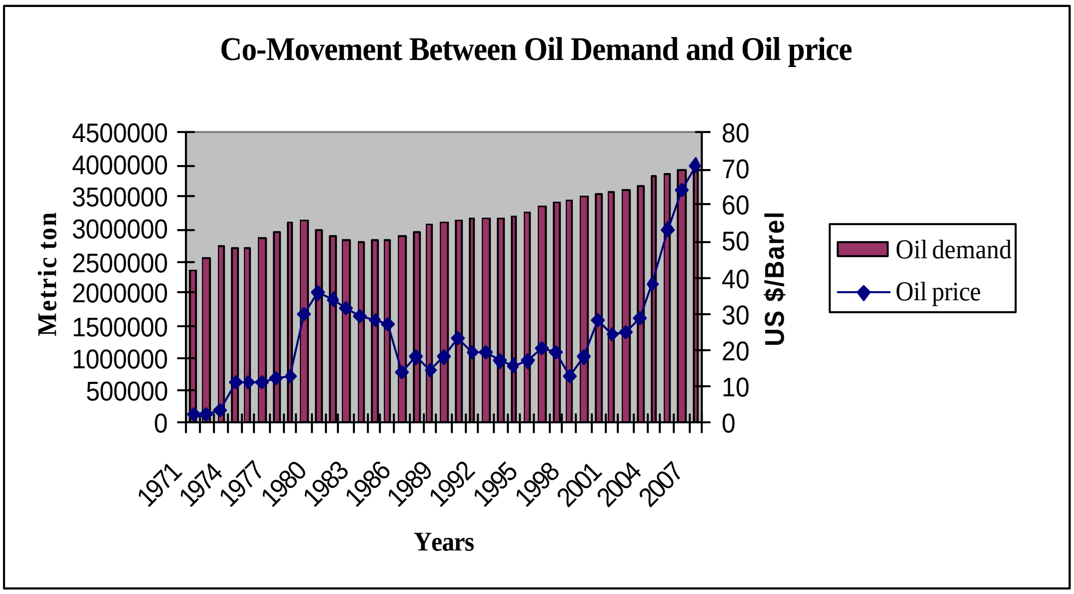
Pirog (2005) also mentions that as China and potentially India (the new major oil importers) expand their demand, it is likely that the oil market will have to expand production capacity. This promises to increase the world's dependence on the Arabian Gulf members of OPEC, especially Saudi Arabia, and maintain the upwards pressure on price.

In recent studies, Kilian (2007) states that an increase in precautionary demand for crude oil causes an immediate, persistent and large increase in the real price of crude oil. An increase in aggregate demand for all industrial commodities causes a delayed but sustained increase in the real price of oil that is also substantial. Also Kilian (2008) reveals that most oil price shocks since the 1970s have been driven by a combination of strong global demand for industrial commodities (including crude oil) and expectation shifts that specifically increase precautionary demand for crude oil.

However, there has been a persistent upward trend in oil prices over the last few years associated with repeated unanticipated increases in oil demand as GDP growth has been higher than expected, particularly in emerging economies, particularly those of Asia (IMF, 2005). Figure 1.1 illustrates the positive correlation between oil demand and oil price over time.

It is clear that the demand for oil plays a crucial role in determining oil price. On the other hand Saudi Arabia plays a significant role in policy decisions with regard to oil

Figure 1.1 Co-Movement between Oil Demand and Oil Price



Source: Compiled by Author Using Data from ESDS (IMF).

prices and regulating the global supply of oil as long as it continues to play the dominant role of filling the gap in global oil demand. Accordingly, the aim of this study is to carry out a quantitative analysis on the potential impact of the rise in oil demand and oil prices on the Saudi economy. The macroeconomic and sectoral effects are evaluated with the help of a computable general equilibrium (CGE) model. I examine the effects of an increase in world oil demand on the Saudi economy under the dominant firm model. This would permit a better understanding of the dimension of the problem faced by oil exporting countries when the oil market is faced with a dramatic change. Following sections throw some light on the expected effects of an increase in oil demand by the rest of the world on the Saudi economy.

v. Effect of Increase in World Oil Demand on Saudi Economy

As mentioned earlier, it is common that an increase in oil demand is usually followed by an increase in oil prices. The impact of oil price changes depends on whether the country is a net exporter or net importer. The net exporter of oil should benefit from the windfall profits and fiscal revenues created by oil price hikes, while the net importers of oil will experience additional burdens on their economies resulting from increased prices of oil imports according to Berument and Ceylon (2000). My concern in this experiment focuses on Saudi Arabia, a net exporter of oil. I examine a 5% increase in world oil demand and its effects on oil prices and the ultimate effects on the Saudi economy. Oil demand shifted rapidly during the previous oil shock. The annual growth rate of world oil fluctuated between 3.3% and 35% during the period 1973-2000[3]. However, a 5% increase was chosen to reflect a moderate shock since the country has a sizable petroleum sector.

Saudi crude oil production is run by the government, which sells on both the domestic and foreign markets and sets the domestic oil product prices. Here, I assume that the domestic price of crude oil is exogenously given since the government

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[3]Author's calculation depending on IMF data.

subsidises the domestic oil price and keeps it below the world oil price.

According to the dominant firm model, Saudi Arabia sets the world oil price through control of oil production. It maintains its role as a swing producer sacrificing market share in an effort to prop oil prices up or down. The rest of the world supplies oil up to the point where the oil price is equal to marginal cost, and Saudi Arabia supplies the remaining amount to satisfy world demand. Hence, the supply of the rest of the world $(ROWOS)$ is upward sloping.

$$ROWOS = \overline{ROWOS} \cdot PWE_c^{e_{rowso}}; \;\; c \in CO \qquad \text{(i)}$$

The Saudi export demand is derived residually to match world market equilibrium:

$$QE_c = ROWOD - ROWOS; \quad c \in CO \qquad \text{(ii)}$$

On the other hand world demand can be formulated as the following equation:

$$ROWOD = \overline{ROWOD}\left[(1 + to)PWE_c\right]^{-e_{rowod}}; \quad c \in CO \qquad \text{(iii)}$$

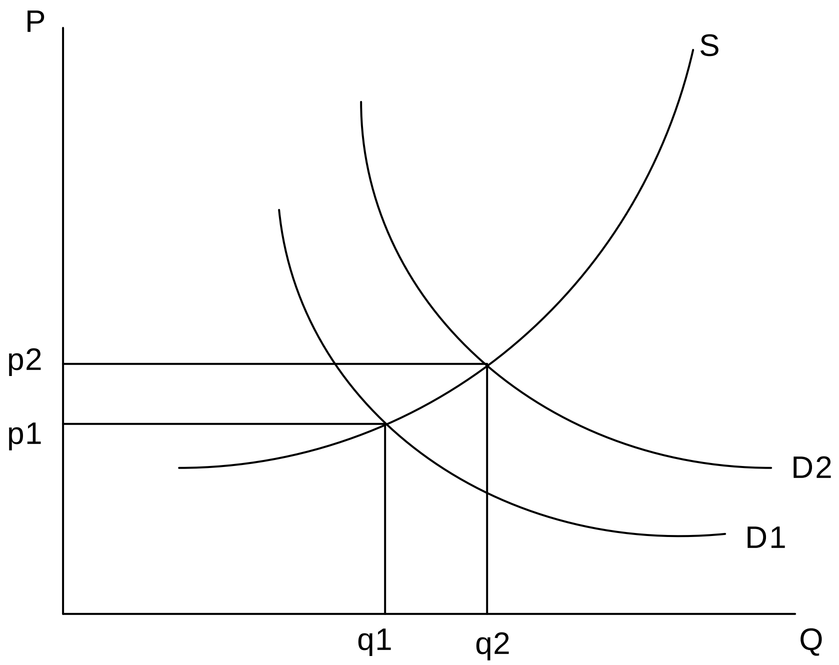
The simulation of the positive demand shock is carried out by increasing the parameter $\overline{ROWOD}$ from the base year (2000) in equation (iii) by 5%.

Figure 1.2 illustrates the mechanism of increasing oil demand by the rest of the world and the following increase in the oil price.

The concern in this experiment is to examine the effect of oil demand change on GDP, household's consumption, labour market, government expenditure, government investment, total export, total import, oil profit in Saudi Arabia and the ultimate effect of household welfare. The model is sensitive to closure rule changes. So, in this experiment I carry out two simulations based on the type of investment-savings closure to explore the possible changes on the Saudi economy.

First Simulation (SIM-1): Examines the effect of an increase in the oil demand

Figure 1.2 Shifts in Oil Demand and Oil Price



Drawn by author

Q: Quantity of oil demanded
P: Oil price

by 5% on the Saudi economy adopting savings-driven investment closure, in which saving is fixed and investment is flexible to clear the market.

Second Simulation (SIM-2): Examines the impact of an increase in oil demand by 5% on the Saudi economy assuming investment-driven savings, in which investment is fixed and saving is flexible.

1.5 Tariff Abolition Effects

There has always been a push for trade liberalisation especially the removal of tariffs and non tariff barriers on international trade as it is widely believed that this will lead to welfare improvement and economic growth. Michael et al (1991) identify trade liberalisation as: "any change which leads a country's trade system toward neutrality in the sense of bringing its economy closer to the situation which would prevail if there were no governmental interference".

i. International Trade Agreement: A Brief History

In their book Krugman et al. (2008) discuss the development of international trade agreements. They point out that tariff reduction as a trade policy dates back to the 1930s. In 1930, the United States passed a tariff law, the Smoot-Hawely Act. Under this act, tariff rates rose steeply and U.S. trade fell sharply; some economists argue that the Smoot-Hawely Act helped deepen the Great Depression. Within a few years after the act's passage, the U.S. administration concluded that tariffs needed to be reduced, but this posed serious problem of political coalition building. To reduce tariff rates, tariff reduction needed to be linked to some concrete benefits for exporters. The initial solution to this political problem were bilateral tariff negotiations. Bilateral negotiations, however, do not take full advantage of international coordination. For one thing, benefits from bilateral negotiation may "spill over" to countries that have not made any concessions. For example, if the United States reduces tariffs on coffee as a result of a deal with Brazil, Colombia will also gain from a higher world coffee price. Multilateral negotiations began soon after end of World War II. In 1947, unwilling to wait until the ITO (International Trade Organisation) was in place, a group of 23 countries began trade negotiations under a provisional set of rules that became known the General Agreement on Tariffs and Trade, or GATT. As it turned out, the ITO was never established because it ran into sever political opposition, especially in the United States. So the provisional agreement ended up governing world trade for the next 48 years. In practice GATT did maintain a permanent "secretariat" in Geneva, which every one referred to as" the GATT". In 1995, the World Trade Organisation, or WTO, was established. It is like a device designed to gradually push the world economy towards free trade.

ii. Tariff Liberalisation and Developing Countries

International trade economists have commonly argued that an open trade regime is very important for economic development and developing countries should rely more heavily on the market mechanism and should liberalise their economies to international trade. The channels through which trade liberalisation could bring benefits are broad. One of the major purposes of trade liberalisation is to promote economic growth by capturing the gains from trade through a more efficient allocation of resources; greater competition; an increase in the flow of knowledge and investment, a faster rate of capital accumulation and technical progress, improved resource allocation in line with social marginal costs and benefits; access to better technologies. (Polino et al.2004; Dornbush 1992).

Anderson and Neary (2006) point out that tariff reduction serves both domestic and international goals: on the one hand, it raises home welfare; on the other hand, it increases foreign access to domestic markets as required by multilateral trade obligations under the WTO.

Legrain (2006) refers to different studies that have been done supporting the belief that free trade promotes economic growth in developing countries. Studies of nine countries: Chile, Colombia, Egypt, Ghana, India, Israel, Korea, the Philippines and Turkey, showed that liberalising trade led to faster economic growth. These findings were confirmed by studies of 19 countries: Argentina, Brazil, Chile, Colombia, Greece, Indonesia, Israel, Korea, New Zealand, Pakistan, Peru, the Philippines, Portugal, Singapore, Spain, Sri Lanka, Turkey, Uruguay and Yugoslavia.

In Chile, which unilaterally opened up its markets between 1974 and 2000, the economy grew by almost seven per cent a year between 1985 and 2000, and poverty fell by more than half between 1987 and 1998. In Vietnam where poverty has declined by more than two-thirds in a decade and a half in 1988, when the country began to open up, three-quarters of the population lived on less than a dollar a day; by 2004 only a fifth did.

China has witnessed an even more spectacular transformation. Since China began to open up its economy in 1978, it has grown by an average of ten per cent a year. Chinese living standards as measured by GDP per person at purchasing power parity which has risen by more than 370 per cent, a rise of over six per cent a year. In the past two decades, China has witnessed the fastest fall in poverty. China has grown richer by freeing its economy and opening up to the rest of the world. It has embraced international trade and foreign investment. In 1970, China's combined exports and imports were equivalent to four per cent of its national income. That had risen to 50 per cent by 2000. China's share of world exports has risen ten-fold, from 0.6 per cent in 1977 to 5.8 per cent in 2004. A final example of the benefits of trade liberalisation is India. Trade rose from ten per cent of GDP in 1980 to 25 per cent in 2000. Poverty declined substantially, falling from 45 per cent in 1980 to 26 per cent in 2000. Nenci and Pietrobelli (2007) examine whether tariff liberalisation promotes trade in Latin American countries. The empirical result provides statistical support to the view that tariff liberalisation has been instrumental in creating a conductive environment for trade expansion.

In other words the tariff reduction is supposed to help the competitiveness of an economy by reducing the costs of intermediate and capital goods imports in support of domestic production.

iii. Saudi Arabian Accession to the World Trade Organisation (WTO)

On December 11, 2005 Saudi Arabia became 149th member of the WTO and it is required to eliminate trade barriers that oppose a trade liberalisation regime. Saudi Arabia might gain from being a member of the WTO. Saudi Arabia could expand its petrochemical industry to some wider international markets. This might help Saudi Arabia to be recognised as a trading country where the government is diversifying its oil dependent economy. WTO. membership would give Saudi Arabia a better stage from which to press for more favourable tariffs on its products and eventually the removal of energy taxes which it sees as discriminatory. Joining the WTO. could lead to more opportunities for export and accordingly opportunities for more new investment in export oriented industries. Required tariff reductions by the U.S., Japan, and the European Union on petrochemical products will lead to greater price competitiveness for Saudi Arabian products in those markets.

Saudi Arabia has taken a number of steps to align various policies with WTO regulations. To accelerate liberalisation further, the government launched the 10x10 mission (to position Saudi Arabia among the top 10 of the world's most competitive nations by 2010). Saudi Arabia has opened up a wide range of sectors to foreign investment. These include banking, insurance, wholesale, retail and franchise distribution services, telecommunications services and the IT sector. The WTO accession is an important anchor to the broader reform, which led to the World Bank recognizing Saudi Arabia as one of the world's top ten reformers in 2006-07. Saudi Arabia is currently ranked 16 in the World Bank's Ease of Doing Business 2009 index [4]

Over the past few years, the Saudi Arabian government has issued a series of laws governing trade and investment, including the Import Licensing Guidelines & Procedures, the Sanitary and Phytosanitary Measures, the Foreign Investment Act, the Law on Ownership of Real Estate by Non Saudis, the Saudi Arabian Standards Organisation Technical Directives, the Negative List excluded from Foreign Investment, the Trade Information Law, the Enhanced Money Laundering Regulations the Executive Rules of the Foreign Investment Act, the Tax Law, the Real Estate Law, the Capital Markets Law and the Anti-dumping Law.

1.6 Saudi Arabian Policy Taxation

The tax in Saudi Arabia in some aspects is different from other countries around

[4] Saudi Arabia fact book (2009).

the world. Since Saudi Arabia is a Muslim country and base its rules according to the Islamic laws and regulations, taxes are applied accordingly. Zakat is the form of tax required in Saudi Arabia in which all Saudi nationals and companies are obligated to pay Zakat annually. The religious tax (Zakat) is obligatory after a time span of one lunar year passes with the money in the control of its owner (paid by the rich to needy people and charities). Then the owner needs to pay 2.5% of the money as Zakat. (A lunar year is approximately 355 days).

All foreign and Saudi companies are required to pay taxes on their profits earned as stated in Saudi law. Companies with joint-ventures having at least 25% Saudi ownership are exempt from income tax for a period of ten years

Since 1993, the Saudi government decided to exempt foreign companies from taxes to attract foreign participation in the country to develop and improve industrial projects as well as technology transfer in the country. This will result in the expansion of the Saudi capital in various industrial projects. Currently, Saudi law imposes corporate tax on net income. Table 1.1 shows Saudi corporate tax rates range from 25% (on annual taxable income of up to SR 100,000) to 45% (on annual taxable income of over SR 1 million).

However, income tax is not imposed on salary and benefits for non-Saudi employees. Though, if non-Saudis are investing in Saudi businesses and/or professional activities, tax is imposed and it ranges from 5% (for example income up to SR 16,000) to 30% (for taxable income over SR 66,000) depending on the net income received, Table 1.2.

Another type of tax imposed in Saudi Arabia is the custom duty tax. Most of the goods imported from foreign countries are duty free and others are charged at 12% on the total cost which is unified by the Gulf Cooperation Council (GCC) members. Some Saudi industries are charged at high custom duty tax to be protected locally such as Aluminum and Wooden Frames.

GCC in January 2003 has changed the tariff structure in the country. Under this agreement, tariffs have been reduced from 20% and 12% to a uniform 5% for 92% of imported items throughout the GCC, with the proceeds to be share among the member countries on the basis of a pre-approved formula.

- **Subsidizing policy**

Saudi government has applied different policies that benefit consumers and producers, one of these policies is subsidy on selected goods and services. Essentially she aims from this step to encourage industries, lower prices for products and services as well as redistributing incomes. This fundamental approach caused some issues with over consumption of the resources available and misuse of public services such as gas, electricity, fuel, water, etc. because of the lowering the cost of use. If this problem continues, the government intervention will cause over spending of the public and which in contrast causes instability and inefficiencies in many sectors.

There are explicit subsidies and implicit subsidies to support the product and services for the public. Explicit subsidies usually support farmers and utility companies to cover the operating cost. On the other hand, the government provides implicit subsidies to provide products and services at a lower cost for the public i.e. the water is

Table 1.1 Saudi Arabian Corporation Tax Rate

Net Profit Level	Tax Rate (%)
First SR 100,000	25
From SR 100,001 to 500,000	35
From SR 500,001 to 1,000,000	40
Over SR 1,000,000	45

Source: Department of Zakat and Income Tax

Table 1.2 Saudi Arabian Income Tax Rate

Net Income (Per year)	Tax Rate (%)
First SR 6000	Exempted
From SR 6001 to 16,000	5
From SR 16,001 to 36,000	10
From SR 36,001 to 66,000	20
Over SR 66,000	30

Source: Department of Zakat and Income Tax

charged at 60-70% cheaper than the original price. Also Gas is priced a lot cheaper compared to other countries.

1.7 Outline of the Study

The study is structured as follows: Chapter 2 provides an historical perspective on economic developments in Saudi Arabia. It also includes a brief overview of some theoretical and empirical issues regarding growth in transition.

Chapter 3 is the literature review, and begins by developing the conceptual framework of the computable general equilibrium analysis, providing a brief history of its development and a definition. A classification, according to various criteria, is meant to give an introduction to the large variety of CGE models that exist.

Chapter 4 explains the structure of the Saudi Arabian SAM for 2000. It starts with a discussion of the theoretical foundations of a social accounting matrix. Then the structure of the Saudi SAM is explained in detail along with an analysis of the structural relationships among different economic agents (institutional sectors), the pattern of demand and the tax structure. The SAM further serves as a database for the model developed in Chapter 5.

Chapter 5 presents the theoretical foundations of the computable general equilibrium model for the Saudi economy. The Saudi CGE model focuses on the real side of the economy and captures the behaviour of three economic agents: households, the government and the external sector (ROW). In addition it presents the calibration of the CGE model for the Saudi economy. This chapter also talks about closure rules which arise from the problem of deciding which prices and quantities must be made exogenous to derive a model where the number of equations is equal to the number of endogenous variables to assure the model is closed. In addition it presents the calibration of the CGE model for the Saudi economy. Some theoretical aspects regarding the calibration procedure are discussed. Then the calibration of the parameters of Saudi CGE model is presented. The benchmark equilibrium data set used for calibration is the SAM for 2000 presented in Chapter 4.

Chapter 6 starts by explaining the detailed economic effects of five main scenarios, aiming at trade liberalisation and oil exogenous demand shock. This chapter describes the simulation of a number of alternative policy experiments and exogenous shock. In particular, it analyses the following five experiments:

External exogenous shock scenarios:

1. Effect of an increase in world demand for oil on the Saudi economy, when saving are flexible and investment remains fixed.
2. The effects of such an increase but where savings are fixed and investments are left flexible to clear the market.

Trade policy scenarios:

1. Tariff abolition without compensation government revenue declining.
2. Tariff abolition applying sales tax in order to compensate the government revenue decline.
3. Tariff abolition applying income tax in order to compensate the government revenue declining.

The chapter also includes the results of these experiments and compares the results with the base run solution.

Welfare analysis was carried out across households using equivalent variation EV. The study concludes that the first simulation (SIM-1) for the first experiment is better. For the second experiment the third simulation (SIM-3) is preferred in case the government is forced to compensate the reduction in government revenue but the first simulation (SIM-1) is recommended since the compensation can be made through the oil revenue to avoid add more burden on consumers.

It is common in most studies to carry out an examination of the sensitivity analysis of the results to key assumptions. Many assumptions were made with regard to model structure and parameter estimates. The model shows sensitivity to a change in parameter values of either an increase or decrease estimate value. The reasons behind the sensitivity are the monopoly model we adopt and the elasticity values borrowed from De Santis (2003). Finally, Chapter 7 presents some final conclusions and some directions for future research.

In order to clearly understand the impact of external shocks and policy changes on the micro and macro economy of Saudi Arabia, it is important to shed more light on world demand for oil and supply of oil and their mechanisms in addition general speaking about trade liberalization and role of World Trade Organization (WTO) in this particular policy.

1.8 Conclusion

This chapter starts with the main objective of this study namely investigate two major issues: First, an impact of macroeconomic fluctuations as a result of changes in the world demand for crude oil in the Saudi economy. Second, examine the role of fiscal policy as a result of accession the WTO on the Saudi economy.

Then it talks about justification of using CGE model over other approaches such as partial equilibrium or econometric as such development of computable general equilibrium (CGE) models for policy analysis allows us to evaluate outcomes more effectively with numerical estimates. The chapter also outline the structure of the study and finally gives back ground about world oil demand and supply and the mechanism by which affect oil price.

Chapter 2
The Saudi Arabian Economy

For a proper understanding of oil demand and oil price as well as liberalisation regime effects on the Saudi Arabian economy, it will be necessary to outline the structural features which characterise the economy.

2.1 Gross Domestic Product (GDP)

The value of GDP rose from about SR 129,216 million in 1969 to SR 789,592 million in 2006 at annual growth rate of 5.49% (Table 2.2.). With the exception of the seventies, modern economic growth of Saudi Arabia was marked by general economic stability, reduction in inflation rates and maintenance of the Saudi Riyal (SR) purchasing power. This has helped improve the efficiency of economic decisions by producers, investors and consumers. The average annual rate of increase in the general consumer price index, which was 12.8% during the 1969-1979 period, dropped to 1.8% during the period 1979-2007 (largely due to development plans).

The development plans have succeeded in bringing about significant changes in the structural characteristics of the national economy which had depended enormously upon crude oil production and exports. This was made possible through the diversification of economic activities, increasing the contribution of non-oil sectors in GDP formation, as well as increasing the role of the private sector in production, investment and employment.

During the first five year development plan (1970-1974), the Saudi economy showed remarkable growth at a rate which coincided with the hiking of oil prices. This

Table 2. 1 GDP Growth and Oil Price US $/barrel

Year	Arabian Light Oil Price US $	GDP growth	Year	Arabian Light Oil	GDP growth
1970	1.3	12	1988	13.4	-4
1971	1.65	20	1989	16.21	7
1972	1.9	24	1990	20.82	0
1973	2.7	26	1991	17.43	8
1974	9.76	28	1992	17.94	9
1975	10.72	5	1993	15.68	4
1976	11.51	13	1994	15.39	0
1977	12.4	7	1995	16.73	1
1978	12.7	-1	1996	19.91	0
1979	17.26	10	1997	18.71	3
1980	28.67	7	1998	12.2	3
1981	34.23	5	1999	17.45	3
1982	31.74	-11	2000	26.81	-1
1983	28.77	-8	2001	23.06	5
1984	28.06	-3	2002	24.32	1
1985	27.54	-4	2003	27.69	0
1986	13.73	5	2004	34.53	8
1987	17.23	12	2005	50.15	5

Source: Saudi Arabia Monetary Agency

Table 2.2 Gross Domestic Products by Sector at Constant Price 1999, (SR Million)

Year	GDP	Oil Sector	Non-oil Sector			Year	GDP	Oil Sector	Non-oil Sector		
			Total	a)Private	b)Government				Total	a)Private	b)Government
1969	129,216	80,445	48,771	18,855	29,916	1988	437,192	140,769	296,423	193,481	102,942
1970	145,037	95,362	49,675	18,753	30,922	1989	439,238	136,966	302,272	196,827	105,445
1971	173,772	117,466	56,306	22,511	33,795	1990	476,225	170,076	306,149	197,041	109,108
1972	215,107	146,886	68,220	30,385	37,835	1991	520,999	207,911	313,088	200,866	112,222
1973	271,336	183,796	87,540	43,442	44,098	1992	542,726	214,109	328,617	208,908	119,709
1974	347,508	205,987	141,521	88,400	53,121	1993	542,927	207,491	335,436	212,868	122,568
1975	365,829	171,508	194,321	130,689	63,632	1994	547,799	207,889	339,910	215,719	124,191
1976	412,825	211,494	201,330	135,643	65,687	1995	549,963	206,972	342,990	217,644	125,346
1977	441,024	225,530	215,494	142,758	72,736	1996	567,550	211,879	355,671	228,397	127,274
1978	437,054	205,812	231,241	157,504	73,737	1997	582,438	208,724	373,713	238,705	135,008
1979	480,784	235,341	245,443	172,677	72,766	1998	598,154	215,357	382,796	244,891	137,905
1980	512,403	245,843	266,560	187,841	78,719	1999	593,955	198,988	394,967	255,200	139,767
1981	537,048	243,580	293,468	209,124	84,344	2000	623,237	212,652	410,585	266,437	144,148
1982	476,916	167,454	309,461	222,289	87,172	2001	629,265	204,365	424,900	276,254	148,646
1983	437,023	122,932	314,090	223,020	91,070	2002	629,772	189,112	440,660	287,667	152,992
1984	423,111	112,160	310,950	214,356	96,594	2003	678,183	221,545	456,638	298,970	157,668
1985	404,685	92,525	312,160	208,543	103,617	2004	713,899	236,459	477,440	314,924	162,516
1986	425,166	131,162	294,004	190,879	103,125	2005	757,208	254,974	502,233	333,200	169,034
1987	408,752	116,103	292,649	190,081	102,568	2006	789,592	255,501	534,091	354,665	179,426

Source: Saudi Arabia Monetary Agency

increase in oil prices was due to two significant factors: First shock due to the Arab-Israeli war in 1973 which led to the Arab oil embargo. This shock was the major reason for the oil price increase from about US $1.3 per barrel in 1970 to about US $10 per barrel in 1974. The second positive shock was due to the Iranian Revolution and Iran-Iraq war in 1979 and 1980 respectively. Prices increased more than three-fold from about US $10 in 1974 to about US $34 per barrel in 1981. (See Table 2.1 and Figure 2.2.)

The oil sector dominates other sectors generating a tremendous amount of revenue to the state budget. During the first plan the GDP grew from SR 145,037 million in 1970 to reach SR 347,508 million in 1974, which amounted at an average annual growth rate of 22.01% thanks to improvement in oil GDP (Table 2.3.)
The increase in oil production and prices resulted in substantial increases in government revenue and allowed the government to spend heavily on infrastructure and domestic services. In addition, there was a rapid expansion of the private sector that runs industries and businesses. The achievements of the first development plan state:

> *"The plan was prepared in the prospect of severe financial constraint. Revenue began to improve during the first year of the plan and by the second year, it became clear the financial resources should no longer be considered a constraint on development. A policy was then adopted of accelerating implementation of the plan and expanding it with new programs and projects that were consistent with the objectives of the plan and were economically and socially feasible." (p 10)*

GDP per capita had risen from SR 3,185 million in 1970 to SR 23,980 million in

1974. It is important to note that the average annual rate of increase over the first plan period estimated for general administration and for defense was only 7.0% and 5.9% respectively, whereas, for health and education, the estimated average annual rates were 16.3% and 14.1% respectively. It is clear from this that the government's attention was focused on the two areas most crucial for future welfare and progress.

As it was reported in the second development plan (1975-1979), the second shock as mentioned above took place during this period. The economy continued to grow, hence, total GDP, which is influenced by the level of oil output and exports, grew from SR 365,829 million in 1975 to SR 1480,784 million in 1979 at an average annual growth rate of 6.8% during the period, the average annual rate of growth in the non-oil economy accounted for over 3.76% of GDP. Inflation was brought under control, and productivity substantially improved. The oil price increase to about US $ 34 per barrel by the end of this plan period, and the surge in demand for oil resulted in increases in revenue as well as government spending. This is discussed at the end of this section.

The third development plan (1980-1984) was characterised by slow economic growth. GDP decline from SR 512,403 million in 1980 to SR 423,111 million in 1984 (Table 2.2) the negative average annual growth rate for GDP (-0.15%) due the deterioration of oil GDP growth (-12.61%) which decline from SR 245,843 million 1980 to SR 112,160 million in 1984. The period was also characterised by severe government deficits and a recession. In addition, the decline in oil prices in 1982 resulted in a massive fall in government revenue in the following years.

Table 2.3 Growth of GDP, GDP-Oil and GDP Non-Oil Sectors(Constant price 1999)

Year	GDP	Oil	Non-Oil		Year	GDP	Oil	Non-Oil
1969	6.01	5.35	7.12		1988	6.96	21.24	1.29
1970	12.24	19.00	1.85		1989	0.47	-2.70	1.97
1971	19.81	23.18	13.35		1990	8.42	24.17	1.28
1972	23.79	25.05	21.16		1991	9.40	22.25	2.27
1973	26.14	25.13	28.32		1992	4.17	2.98	4.96
1974	28.07	12.07	61.66		1993	0.04	-3.09	2.08
1975	5.27	-16.74	37.31		1994	0.90	0.19	1.33
1976	12.85	23.31	3.61		1995	0.40	-0.44	0.91
1977	6.83	6.64	7.04		1996	3.20	2.37	3.70
1978	-0.90	-8.74	7.31		1997	2.62	-1.49	5.07
1979	10.01	14.35	6.14		1998	2.70	3.18	2.43
1980	6.58	4.46	8.60		1999	-0.70	-7.60	3.18
1981	4.81	-0.92	10.09		2000	4.93	6.87	3.95
1982	-11.20	-31.25	5.45		2001	0.97	-3.90	3.49
1983	-8.36	-26.59	1.50		2002	0.08	-7.46	3.71
1984	-3.18	-8.76	-1.00		2003	7.69	17.15	3.63
1985	-4.35	-17.51	0.39		2004	5.27	6.73	4.56
1986	5.06	41.76	-5.82		2005	6.78	-7.53	12.03
1987	-3.86	-11.48	-0.46		2006	3.16	-1.12	4.89

Calculated by Author, Data Source: Saudi Arabia Monetary Agency (SAMA)

The GDP share of non-oil sector rose from about 52% in 1980 to about 77% in 1985 (Table 2.4.) The main cause of this major transformation has been the sharp decline of the oil sector, as crude oil exports fell from over 9 million barrels per day (mbd) in 1982 to less than 4 mbd in 1985. The steady increase in the GDP share of the non-oil sector is also an indication of the continuous diversification of the economy (Table 2.3.)

The further worsening of world oil market growth was observed early in the fourth development plan years (1985-1989). GDP fluctuated through the plan, declined to SR 404,685 in 1985 million compare to 1984 increased to SR 425,166 million in 1985 then dropped to SR 408,752 million in 1986 but recovered by the end of the period to reach SR 439,238 million in 1989 (Table 2.2), GDP stood at an average annual growth rate of 3.41% during the plan (Table 2.3) this situation caused government revenues to fall short of their anticipated level. Accordingly expenditures rapidly reduced resulting in an overall decline in government spending to 20% below the fourth plan target.

In fact a clear trend emerged during the fourth plan period with emphasis on high value-added industries, led by petrochemicals, which grew from -0.10% at the beginning of the plan to about 1.97% in 1989. Other highlights of the plan include obviously positive indicators, such as an increased share of non-oil exports from 3.4% to 15.1% in total exports, and a decline in imports at an average rate of 7.9% a year, reflecting the growing role of domestic production, particularly of consumer and agricultural goods, in import substitution.

The invasion of Kuwait and the subsequent outbreak of the Gulf War (1990) presented enormous organisational and financial challenges to the Saudi economy in the early years of the fifth development plan (1990-1995). There followed a period of substantial investment activity, as the private sector responded to higher government expenditures in the economy and a rise in consumer spending. There followed a dramatic increase in expenditure in response to the gulf crisis, so that in the second year of the fifth plan (1991/92) government expenditure rose to its highest level in ten years.

In the first year of the fifth plan, Saudi Arabia responded to the cutback in world oil supplies (due to the Gulf War) by raising its crude oil production. As a result the oil revenue position changed dramatically. Although the initial increase in production was sustained, falling oil prices led to a decline in revenues in the last two years of the plan from SR 127,264 million in 1991 to SR 95,505 million and SR105,728 million in 1994 and 1995 respectively - Table 2.5.

Non-oil revenues on the other hand showed a downward trend in the early years of the fifth plan from SR 38,700 million in 1989 to SR 30,327 million in 1990 (Table 2.5) as the draw-down in the reserves reduced the flow of investment income from abroad. With the recovery of economic activity after the war, however, non-oil revenues began to rise again. Despite the negative impacts of the Gulf War, the private sector has emerged more active, independent and dynamic at the end of the fifth plan.

During the sixth development plan (1995-2000) the inflation rate averaged 1.2% per year, which is well below international levels. Contribution of non-oil sectors, as a share of GDP, rose from 62% in 1994 to about 66% in 1999 (Table 2.4) due to a world oil price rise, which led to increased revenues and further contribution to the Saudi GDP. Private sector investments grew during the course of the sixth plan at an average annual rate of about 6.41% levelling to about 6.1% in 2000. Government expenditure

Table 2.4 Share of Oil GDP and Non-Oil GDP in Total GDP

Year	Total	Oil % share	Non-oil %Share	Year	Total	Oil % Share	Non-oil % share
1968	100	63	37	1987	100	28	72
1969	100	62	38	1988	100	32	68
1970	100	66	34	1989	100	31	69
1971	100	68	32	1990	100	36	64
1972	100	68	32	1991	100	40	60
1973	100	68	32	1992	100	39	61
1974	100	59	41	1993	100	38	62
1975	100	47	53	1994	100	38	62
1976	100	51	49	1995	100	38	62
1977	100	51	49	1996	100	37	63
1978	100	47	53	1997	100	36	64
1979	100	49	51	1998	100	36	64
1980	100	48	52	1999	100	34	66
1981	100	45	55	2000	100	34	66
1982	100	35	65	2001	100	32	68
1983	100	28	72	2002	100	30	70
1984	100	27	73	2003	100	33	67
1985	100	23	77	2004	100	33	67
1986	100	31	69	2005	100	33	67

Calculated by Author, Data Source: Saudi Arabia Monetary Agency (SAMA) grew from SR 173,943 million in 1995 to SR 235,322 million at a growth rate of about 35.29% (Table 2.5.)

For the seventh development plan (2000-2004), while the Saudi GDP achieved good growth rates over the past six development plans, its real value [in constant prices of (1994)] increased by four folds. The value of the GDP increased from SR 129,216 million in 1969 to SR 623,237 million in 2000 (Table 2.2.) This reflects the positive performance of the national economy and growth of non-oil sectors which is also considered as a good indicator for the successful strategy of restructuring the national economy through increasing non-oil sectors contribution to the GDP. The continuous growth of non-oil producing sectors over the past development plans 1969-2000 emphasizes the great efforts applied by Saudi Arabia towards ensuring sustainable development of the national economy. The average annual growth rate of the non-oil sectors GDP reached 8% during the same period.

By the first year of the seventh plan (2000) the state budget realised a surplus of SR 22,740 million at annual growth rate of 4.93% as a result of improved world oil market conditions and policies that were aimed at increasing non-oil public revenues. In addition it benefited from the flexible policies of planning methodology and continuous efforts to match the requirements of the present stage with the aspirations for the future. As a result of the economic recession in industrialised nations along with the unusual economic and political events and their impact on the global economic conditions, the state budget experienced a deficit of SR 26,980 million and SR 20,500 million in the second and third years (2001, 2002.). The fourth year of the seventh development plan witnessed a budget surplus of SR 36,000 million due to relative improvements in the performance of the global economy and an increase in demand for oil by about 2.5 % as well as increases in oil prices, resulting from political condition in Nigeria and Venezuela and the instability in Iraq. The growth of the non-oil sector has been accompanied with major positive changes in the structure of the national economy. Foremost among these are the increased share of non-oil producing sectors and the private sector in GDP. Private sector production and service activities have increased whereas private sector reliance on government expenditure has decreased.

The state budget has successfully withstood oil price fluctuations in international markets and their impact on government revenues. This was because of continuous increases in non-oil revenues. By the first year of the seventh plan, non-oil revenues stood at about SR 43,641 million and reachs by the end of the fifth year to SR 62,291 million at average annual growth rate of 3.87% (Table 2.5).

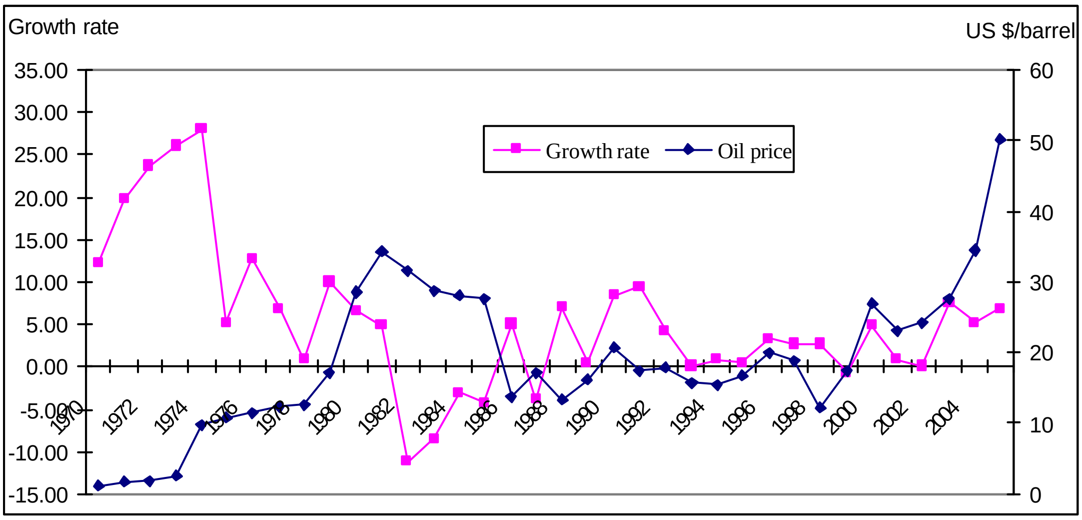
2.2 Private Sector Investment

For a long time, economic development in Saudi Arabia was marked by the major role played by the oil sector in generating GDP and financing government expenditure to establish the infrastructure and provide public services to citizens. In response to this situation, the top priority of the successive development plans have persistently focused on diversification of economic activities and boosting the private sector role in the economy. Priority was given to the development of petrochemical industries and investments and help was made available to them.

The government encouraged an increased participation of the private sector to expand its share and contribution to the national economy by adopting the best available means within the scope of the national development plan. The resolution identified eight objectives of privatisation:

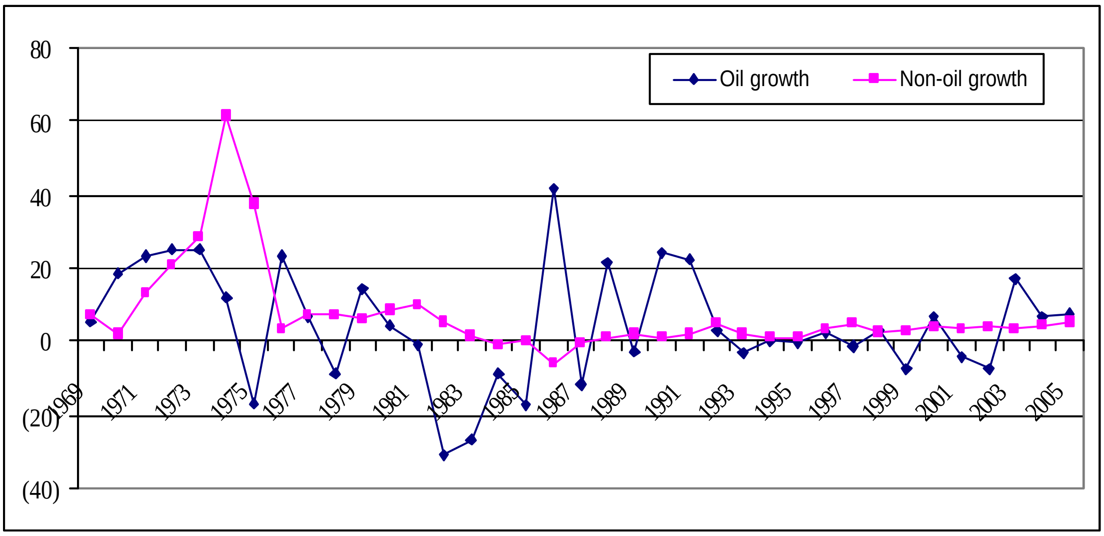
1. Enhance the efficiency and competitiveness of the national economy to face regional and international challenges.
2. Encourage private sector investment and its effective participation in the national economy to increase its share of GDP in a manner that would realise growth in the economy.
3. Broaden the participation of citizens in the ownership of productive assets.
4. Encourage national and foreign capital to invest inside the kingdom.
5. Increase job opportunities and optimal employment of national labour and continue to realise an equitable increase in per capita income.
6. Provide affordable and timely services for citizens and investors.
7. Rationalise public expenditure and alleviate the burden on the state budget through allowing the private sector to finance some services which it can operate and maintain.
8. Increase government revenues through the returns generated from participation in the activity to be privatised, and through the financial returns accruing from granting concessions and the revenues generated from privatisation of part of the government shares in some projects.

Figure 2.1 GDP Growth Rate and Oil Price



Drawn by Author, Data Source: Saudi Arabia Monetary Agency (SAMA)

Figure 2.2 Growth of Oil GDP and Non-Oil GDP

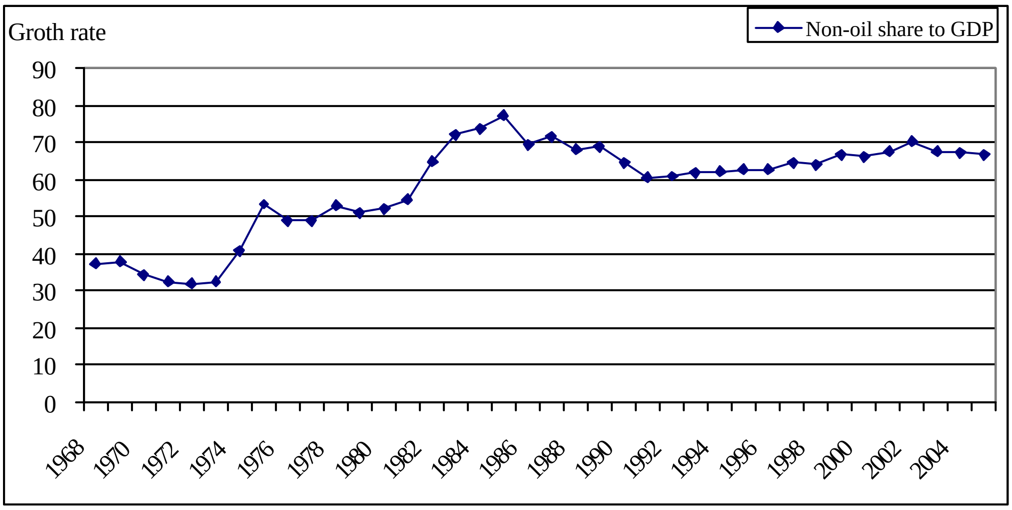


Drawn by Author, Data Source: Saudi Arabia Monetary Agency (SAMA)

It was realized that in the last three decades, the high rise in growth rates in the non-oil sectors were due to a larger contribution by the private sector. Since 1973, the Saudi Arabian economy has experienced a rapid shift from oil sector to non-oil sector activity (Al-Sahlawi et al. 2000). This diversification is reflected in the increasing share of the non-oil sector in total

During the seventh development plan (2000-2005), non-oil sectors achieved real growth rate that averaged 3.87%, thus increasing its GDP contribution to some 67% in 2004 (Table 2.3 and 2.4.) This was made possible as a result of the expansion of private investment which posted a real growth rate averaging about 3.5% during the plan period (plan achievements, 2007). The value of non-oil GDP increased at an average annual growth rate of about 7.38% or seven-fold over the period 1969-2006. (Table 2.3.)

Figure 2.3 Non-Oil Share in Total GDP



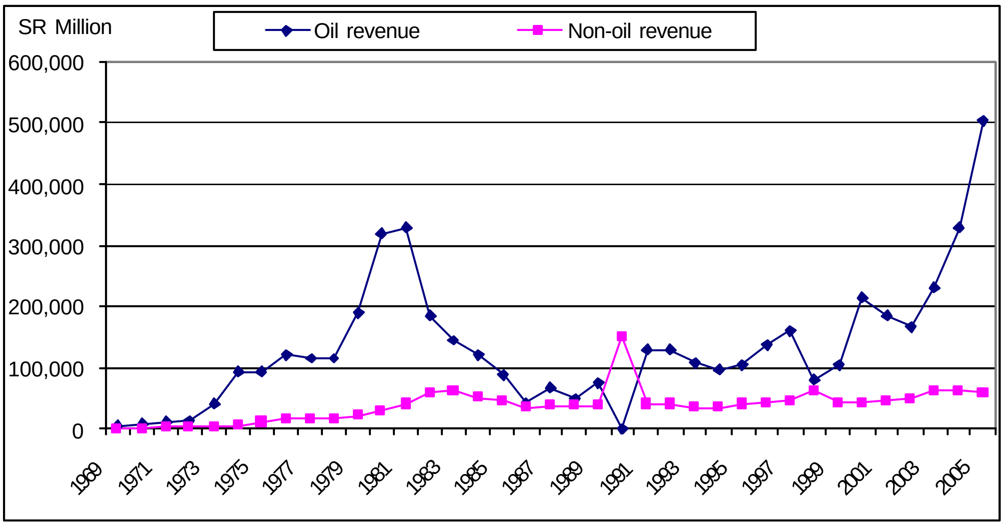
Source: Saudi Arabia Monetary Agency (SAMA)

2.3 Government Revenues and Expenditure

i. Government Revenues

Figure 2.4 shows the oil and non-oil revenue trend during the period 1970-2005. Oil revenues played a vital role in economic development in the past decades. Despite the expansion and diversification of the economic base, these revenues still represent the largest share of the state budget. Non-oil revenues could not cope with the expansion of the economic base, leading to increased dependence on oil revenues for general investment and operational expenditures of the state budget. However, revenue from oil resources, which are non-renewable by nature, should best be invested in renewable assets that would contribute to diversifying the economic base and achieving sustainable development. It is, therefore, essential for non-oil public revenues to be enhanced, so that oil revenues may be gradually transformed into productive assets and effective human capital.

Figure 2.4 Oil and Non-Oil Revenue



Drawn by Author, Data Source: Saudi Arabia Monetary Agency (SAMA)

The government is the sole owner of oil and it operates all oil related activities through the Saudi ARAMCO company. The oil industry supplies the Saudi economy with vast amounts of capital inflow and revenue derived from oil which goes directly into the government account, enabling the Saudi government to fund social and economic programs.

Oil revenue dominated government revenues during the 1970s. The average annual growth rate accounted for 53% and the share of oil revenue ranged between 80% and 90% of total government revenue. The growth in oil revenue during this period is attributed to the oil boom of 1973-81. However, due to the decline in exports and in oil prices in the mid and late eighties, Saudi Arabia witnessed a significant decline in oil revenues. The oil price slumped from US $34.23 per barrel in 1981 to US $13.73 per barrel in 1986 which led a decline in the share in total revenue from 94% to 56% in 1986 and the growth rate declined to -87.08 and the average growth rate during the same period was -14.51%. Growth rate and share of oil revenue continue to fluctuate until 2000 when the oil revenue share reached 83% and the average growth rate was 28.93% over the same period. The increase in oil revenue continues to the present which was contributed to enhancing the non-oil sector in the process of diversifying the Saudi economy as discussed at the end of this section (Table 2.1 and Table 2.5.)

Despite its wealth, Saudi Arabia suffered a yearly budget deficit from 1983 to 2002 (with the exception of 2000 due to high oil prices that resulted in an actual budget surplus of 3.3% of GDP). Al-Hassoon (2005), points out that in 1986 the deficit reached 19.4% of GDP primarily as a result of high military spending, subsidies for utilities and lower oil prices and lower oil production. The Gulf conflict in 1990-91 increased the deficit by about SR 115.5 billion in emergency-related expenditures. Another drop in oil prices in 1999 drove the deficit to about 10.6% of GDP and in actual fiscal deficit was about 6% GDP. By the end of 2003 the government declined a budget surplus of about 5.8% of GDP following a 2% reduction in government expenditures.

Non-oil revenues on the other hand played a vital contribution in the government revenues particularly petrochemical products. The Kingdom built two industrial cities at Jubail and Yanbu. The two cities, with their 218 establishments employing more than 85,000 workers, have attained a distinguished status in the production of petrochemicals, both regionally and internationally, Saudi Arabia met around 7.6% of world demand for petrochemicals (development plan, 2003).

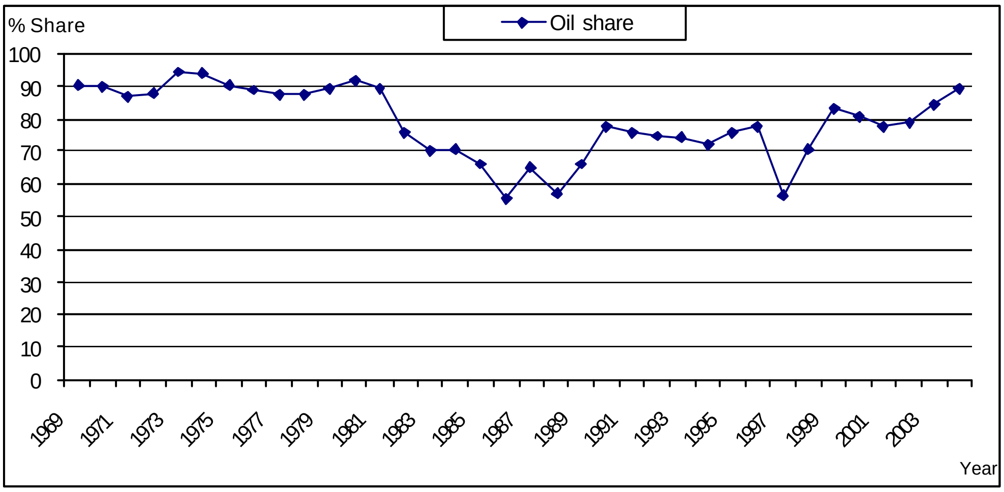
Table 2.6 shows the expected impact of economic diversification on the structure of exports. These will shift considerably to "non-oil exports", such as those of manufacturing industries, petrochemicals, oil refining, mining and other non-oil exports, whose share will increase from 20.7% at the end of 2004 to about 53.7% by the end of 2024. These trends will assist to a great extent in enhancing the role of non-oil revenues in financing the development process.

Table 2.5 Government Total Revenue and Expenditure (SR Million)

Years	Oil Revenue	Other Revenues	Total Revenue	Oil share as % of Total Revenue	Total Expend-iture		Years	Oil Revenue	Other Revenue	Total Revenue	Oil share as % of Total Revenue	Total Expend -iture
1969	5119	549	5668		--		1988	48400	36200	84600	57	134850
1970	7122	818	7940	90	6418		1989	75900	38700	114600	66	149500
1971	9685	1435	11120	87	8303		1990	119033	30,327	149360	80	199,360
1972	13480	1888	15368	88	10148		1991	127,264	40,015	167360	76	258117
1973	39285	2420	41705	94	18595		1992	128790	40857	169647	77	211340
1974	94190	5913	100103	94	32038		1993	105976	35469	141445	75	187890
1975	93481	9903	103384	90	81784		1994	95505	33486	128991	74	163776
1976	121191	14766	135957	89	128273		1995	105728	40772	146500	72	173943
1977	114042	16617	130659	87	138048		1996	135982	43103	179085	76	198117
1978	115078	16427	131505	88	147971		1997	159985	45515	205500	78	221272
1979	189295	21901	211196	90	188363		1998	79998	61610	141608	56	190060
1980	319305	28795	348100	92	236570		1999	104447	43007	147454	71	183841
1981	328594	39412	368006	89	284650		2000	214424	43641	258065	83	235322
1982	186006	60176	246182	76	244912		2001	183915	44244	228159	81	255140
1983	145123	61296	206419	70	230185		2002	166100	46900	213000	78	233500
1984	121348	50161	171509	71	216363		2003	231000	62000	293000	79	257000
1985	88425	45140	133565	66	184004		2004	330000	62291	392291	84	285200
1986	42464	34034	76498	56	137422		2005	504540	59795	564335	89	346474
1987	67405	36406	103811	65	173526							

Source: Saudi Arabia Monetary Agency (SAMA)

Figure 2.5 Oil Share to Total Revenue



Drown by Author, Data Source: Saudi Arabia Monetary Agency (SAMA)

Table 2.6 Exports Structure at Beginning and End of Strategy Period 2004-24 at 1999 Constant Prices

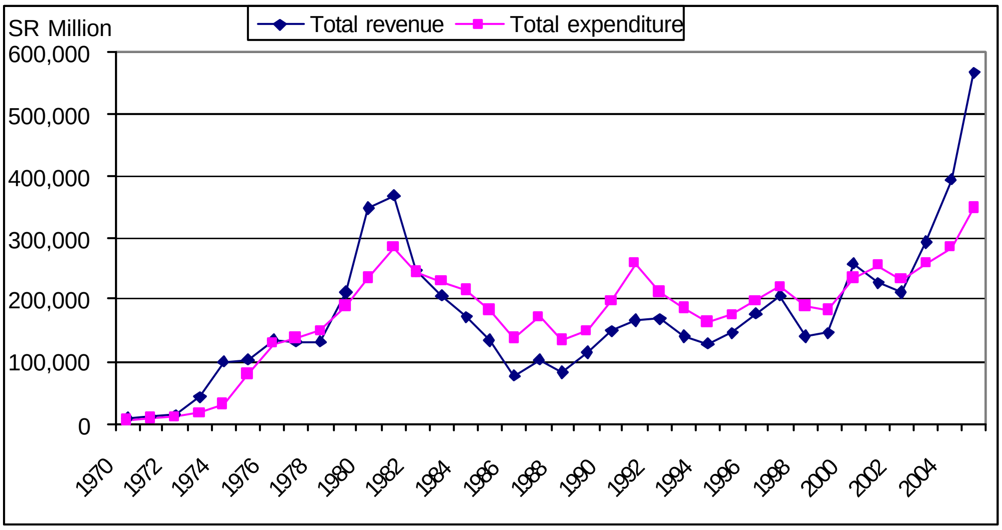
	2004		2024	
	Value SR billion	**%**	**Value SR billion**	**%**
Oil and Gas Exports	181.04	71.7	294.41	36.70
Others Exports*	52.22	20.7	430.69	53.70
Services Exports	19.09	7.6	77.39	9.60
Total Exports	252.35	100	802.49	100

Source: Macroeconomic Projections, Ministry of Economy and Planning.
*Including, petrochemicals, oil refining, mining and other manufacturing industries and agriculture.

ii. Government Expenditure

In the context of the financial requirements of the development plans in socio-economic fields, to realise the strategic objectives of boosting economic growth and social welfare, improving living standards of the citizens, and expanding public facilities and services, major increases have been experienced in government expenditure. It jumped from SR 6,418 million in 1970 to SR 346,474 million in 2005 about a 54-fold increase, in order to continue with improving housing, education, health, transport, communication services and developing agriculture and industrial sectors as well as accelerating the implementation of development programs. (Table 2.6 and Figure 2.6.)

Figure 2.6 Government Total Revenue and Expenditure



Drown by Author, Data Source: Saudi Arabia Monetary Agency (SAMA)

Al-Qudair (2003) in his study about the relationship between revenue and expenditure concludes that the policy implication of the results suggest that there is interdependence between government expenditure and revenue. The government makes its expenditure and revenue decision simultaneously due to heavy reliance on oil revenues.

The 1990s witnessed the invasion of Kuwait by Iraq (Gulf War) and the Saudi economy experienced further budgetary deficits due to the increased cost of funding the war. Government spending increased to SR199,360 million and SR258,117 million in 1990 and 1991 respectively - Table 2.5.

Al-Qudair also mentions that growing government expenditure associated with a sharp drop in government revenues, caused by the persistence fluctuations in oil prices in recent years, have largely contributed to the accumulating national debt that was estimated to be SR637.5 billion in 2002. Furthermore, the major components of government expenditure are wages and salaries to the government employees which are difficult to cut in times of declining revenues. This represents a dilemma to the policy makers who are trying to keep up the thrust into the economy by injecting more government expenditure into domestic economy while at the same time faced with declining oil revenues.

The situation has changed in successive years. Global (2009) reports that the country made windfall oil revenues in the latest oil boom projecting total revenues of SR1,100 billion in 2008 (i.e. an annual increase of 71% over actual 2007 total revenues) and a record budget surplus of SR590 billion, versus expenditure of SR510 billion. The last half of 2008 experienced a severe global economic slowdown and extreme volatility in oil prices has dramatically changed global economic outlook, also affecting Saudi Arabia that has budgeted the fiscal deficit of SR65 billion in 2009. This is the first time the government has budgeted for a deficit since 2004[5].

2.4 Oil market and Saudi Role

Saudi Arabia's spare crude production capacity enabled it to ensure oil market stability throughout a number of world supply disruptions from Iraq's invasion of Kuwait in 1990, to the crippling 2002 strike in Venezuela, unrest in Nigeria and the U.S. invasion of Iraq in 2003. As a result of Saudi Arabia using its spare crude production capacity, world oil prices at the peak of each of these physical disruptions were lower than they were at their onset (Obaid and Ken, 2005). The role of Saudi Arabia in the world oil market is based on its substantial oil reserves and being the world largest exporter. In the 2005, Saudi Arabia's land-base contained 264.3 million barrel or 25% of the world's proven crude oil reserves, and over 30% of OPEC's reserves, Saudi Arabia has consistently earned more oil export revenue than any other single member of OPEC with 32% the oil export revenue of OPEC in 2005(EIA,2005).

Generally speaking the government of Saudi Arabia shapes it's oil policy to achieve several broad objectives: The successful execution of the country economic plans; the maintenance of Saudi Arabia's economic, political and security relations with it's western partners (especially the U.S.); the fulfilment of it's obligations to the OPEC's goals and the achievement of orderly conditions in the world oil markets.

Between 1973 and 1980, Saudi Arabia was able to exercise significant influence over the international oil market because it had the capacity to change its output and

[5] http://www.marketskeptics.com/2008/12/saudi-arabias-2009-budget-deficit.html

control the price of oil, acted as a swing producer by changing its own production levels in order to maintain overall production by OPEC members and to maintain higher oil prices.

During this period two oil shocks have taken place. The first shock was in 1973 as a result of the Arab-Israeli War which led to the Arab oil embargo, the year 1979 was characterised by the Iranian Revolution and 1980 Iran-Iraq war. This war had a significant impact on oil production and prices since Iran is a significant oil producer and OPEC member. In both shocks OPEC's members particularly, Saudi Arabia was able to exercise significant influence over the international oil market because it had the capacity to change its output.

During the period 1979-81, Saudi was producing almost 10 million barrels per day (mdb). Its share of OPEC production increased from 26.1 % in 1975 to 42.6% in 1981. Additionally, the price of Saudi light crude oil jumped from $11 a barrel in 1978 to $40 by the mid-1980. The increased quantity of Saudi exports combined with substantial price increases, raised oil revenue to unprecedented levels.

To sum up, this period experienced the peak of OPEC's glory, power and wealth. During this period OPEC, enjoyed acting as monopolist[6] in the world oil market. It became a dominant organization in determining international oil production, and consequently enjoying massive foreign exchange earnings.

In contrast the period 1981-1986 was considered the worst time for OPEC

[6] Studies of optimal pricing policies for OPEC have treated the cartel as a unified group of countries that all have the same objectives, so that the behavior of the cartel is that of a pure monopolist, Hnyiliczy and Pindyck (1976)."

members and in particular Saudi Arabia. This period was characterised by overproduction and decline in oil demand which resulted in a slump in oil prices. In 1987 OPEC production decreased by more than 43% and Saudi Arabia had to cut its production to create temporary shortages and to increase oil prices. Further disruptions in the cartel caused a sharp decline in oil prices from $34 in 1981 to $13 in 1986. These disruptions were further worsened by the conservative program adopted by the G7 members who reduced their oil consumption IMF (2000)[7]. In addition, some OPEC members were accused of violating their quotas by producing more than their actual allocation. During this period, Saudi Arabia acted as the swing producer by cutting its production in an attempt to stop the fall in oil prices.

By early 1983, OPEC members reached an agreement on a quota system to allocate each member an output ceiling and to allow the role of a residual producer within the OPEC states. Saudi Arabia was reluctant to accept a quota and announced, therefore, that it would become the swing or residual producer within the organisation. As a result, Saudi Arabia paid a markedly high price for becoming a swing producer. The results of adopting this strategy are: A considerable loss in market share; proportionally lower production and government revenues than other OPEC members and massive budget deficits which negatively affected the country's earlier savings.

Accordingly, Saudi Arabia attempted to prevent the decline in oil prices by cutting back on its production. A decline in world demand however, combined with an increase in non-OPEC production, resulted in additional cuts. By 1985, production reached its lowest point at 3.2 mbd. Oil prices, on the other hand, experienced a

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[7] http://www.imf.org/external/pubs/ft/oil/2000/oilrep.PDF

substantial decline during this period. The collective effects of decreased prices and production, led to a dramatic fall in oil revenues.

As a result of volatility in the world oil market, prices of oil dropped to $8 a barrel in August 1986 (the major oil price collapse). This price collapse and the lack of discipline among OPEC countries led to the so called price war strategy. Saudi Arabia, as a result, ended its role as a swing producer and increased oil production to its OPEC quota. By doing so, in the summer of 1987 the country succeeded in raising its production level above 5 mbd. The Iraqi invasion of Kuwait in August 1990 effectively removed some 9% of world oil production from the market and caused considerable uncertainty in the oil market. Saudi Arabia and several other OPEC producers increased production so as to almost entirely offset the loss of the Iraqi and Kuwaiti supplies. During the 1990s oil prices continued to fluctuate between US $12.2 to US $20.82 per barrel. After the Kuwait invasion in 1990, oil prices declined to US $15.39 per barrel in 1994, appreciated to about $20 per barrel in 1996. Asian pacific oil consumption dropped for the first time since 1982 as a result of the Asian financial crisis which caused oil prices to decline to $12 per barrel in 1998.

After the difficult times during the previous period, 2000 to present has proved to be an improvement with the oil price rising dramatically, high productivity growth and significant world demand. crude oil prices exceeded $40 per barrel in the mid-2004 as a result of the unexpected growth in world demand, the Kingdom of Saudi Arabia, accelerated its strategy aimed at expanding both its crude production capacity and its refining capacity around the world and it intends to expand its plans as regards investment in both the upstream and downstream capacity (Obaid and Kern, 2005). The dramatic increase was realised in 2007-2008 when oil prices jumped to $90 and $126 per barrel respectively (EIA, 2010).

2.5 External Sector

2.5.1 Foreign Economic Relations

The Ministry of Commerce is the main agency entrusted with the responsibility for this sector including directing and organising the domestic and foreign non-oil trade activities. It also supervises the process of the Kingdom's entry into the WTO, the work of the National Committee for Trade Finance and the Permanent Committee for Trade and Economic Cooperation with Islamic Countries, as well as chairing the Saudi side in joint economic, trade and technical committees with other countries.

The size and structure of foreign trade are indicators of the level of economic development and competitiveness of an economy. Crude oil plays a vital role in Saudi Arabia as we mentioned earlier. As of today, Saudi Arabia is the world's leading exporter of oil. This has enabled the government to maintain a trade surplus in most cases with its major trading partners such as the United States, Japan, China, and the European Union. Saudi Arabia is the key member of many international organisations such as Organisation of Petroleum Export Countries (OPEC) and The World Trade Organisation (WTO), Cooperation Council for the Arab States of the Gulf (GCC), and Islamic Development.

The significance of Saudi Arabian foreign trade is attributed to the reliance of public revenues on export revenues in financing government expenditures. Saudi Arabia achieved noticeable improvement in exports, in terms of diversification and competitiveness, benefiting from the comparative advantage it has in commodities produced by energy intensive industries, such as petrochemicals, basic minerals and their products, as well as other commodities.

2.5.2 Imports[8]

A major feature of the Saudi Arabian economy is its high degree of interdependence with the world. Since 1973, this interdependence has increased dramatically with the rise in oil revenues. During the period 1970-2007, Saudi Arabia had a significant growth in the overall magnitude of imports. The total value of imports rose from SR3,197 million in 1970 to SR388,088 million in 2007or about 80-fold. (Table 2.7.) The sharp increase in the value of imports may be partially attributed to inflationary trends. However a large portion of the increase in the total value of imports could have been due to the development process that the country was undergoing. (Dodorian et tal. 1994).

Dodorian et al. (1994) also notes that the income elasticity in the long run was found inelastic. Therefore, imports are treated as necessary goods in Saudi Arabia. Although Saudi Arabia, as an oil–producing country, has enjoyed a surplus in its trade balance since 1967, its balance of payments was in deficit during the period 1982-90 as a result of the drop in oil prices and in 1990-91 as a result of Gulf conflict and finally in 1999 after oil price drop as I mentioned earlier in the government revenues section.

The average growth rate of imports during 1968-2007 is about 16% and the highest growth rate of 107% was observed in 1975/76 due to the improvement in oil prices and oil exports, while the lowest growth rate of -27% was recorded in 1984/85

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[8] Since there is no real value available for imports and exports as authority advised, I use current (nominal) values.

for the same period. The growth of imports declined in the 1980s reaching -27% in 1985 because of the slump in the oil prices. The 1990s witnessed a trend growth rate in imports where the annual average growth rate was 3.7%. The highest growth rate of 20.7% was recorded in 1990/91 while the lowest growth rate (-17.2%) was recorded in 1993/94. There was upward growth during 2000-2007. Growth rate jumped from 3.3% in 2000/01 to 32.9% in 2004/05 then declined a bit (17.2%) in 2005/06 and then improved to reach 29.3% in 2006/07 (Table 2.7 and Figure 2.7).

Table 2.8 shows the top ten trading partners in 2003 and in 2007, include the United States, Japan, Germany, China, UK, South Korea, France, Italy, India and Australia. The United States was and still is the first trading partner with Saudi Arabia. The value of imported goods from the USA was SR20,780 million representing about 24% of total import in 2003. By 2007 imports from the USA significantly increased to SR 51,925 million representing 21% of the total imported value and retaining first position among other trade partners. Imports from the United States include military, equipment, machinery, foodstuffs and transport equipment.

Japan, Germany and China occupied the second, third and fourth order respectively among trade partners in 2003, but this order has changed in 2007. Japan became the second then China and Germany with 15%, 14%, and 13% respectively of total value of imports.

In order to shed some light on the structure of imports, Table 2.9 illustrates growth rates for imported commodities during 1999-2003. The value of imports reached SR138.4 billion in 2003, compared with SR105 billion in 1999, a growth at an average

Table 2.7 Growth of Imports, Export and Oil Share in Total Exports (Nominal value,SR Million)

Year	Exports*	Percentage Change	Oil Share (%)	Imports**	Percentage Change	Year	Exports*	Percentage Change	Oil Share (%)	Imports**	Percentage Change
1968	9,118	--	98.94	2,578	--	1988	91,288	5.1	82.85	81,582	8.3
1969	9,496	4	98.80	3,378	31.0	1989	106,294	16.4	84.90	79,219	-2.9
1970	10,907	15	98.79	3,197	-5.4	1990	166,339	56.5	90.31	90,282	14.0
1971	17,303	59	99.73	3,668	14.7	1991	178,624	7.4	91.40	108,934	20.7
1972	22,761	32	99.62	4,708	28.4	1992	188,325	5.4	92.50	124,606	14.4
1973	33,309	46	99.54	7,310	55	1993	158,770	-15.7	91.07	105,616	-15.2
1974	126,223	279	99.76	10,149	39	1994	159,590	0.5	89.47	87,449	-17.2
1975	104,412	-17.3	99.56	14,823	46	1995	187,403	17.4	86.99	105,187	20.3
1976	135,154	29.4	99.66	30,691	107	1996	227,428	21.4	89.34	103,980	-1.1
1977	153,209	13.4	99.70	51,662	68	1997	227,443	0.0	87.80	107,643	3.5
1978	138,242	-9.8	99.61	69,180	34	1998	145,388	-36.1	83.85	112,397	4.4
1979	213,183	54.2	99.74	82,223	19	1999	190,084	30.7	88.51	104,980	-6.6
1980	362,885	70.2	99.85	100,350	22	2000	290,553	52.9	91.44	113,240	7.9
1981	405,481	11.7	99.22	119,298	19	2001	254,898	-12.3	87.93	116,931	3.3
1982	271,090	-33.1	98.71	139,335	17	2002	271,741	6.6	88.03	121,088	3.6
1983	158,444	-41.6	97.74	135,417	-2.8	2003	349,664	28.7	88.20	138,435	14.3
1984	132,299	-16.5	96.63	118,737	-12.3	2004	472,491	35.1	87.86	167,793	21.2
1985	99,536	-24.8	94.36	85,564	-27.9	2005	677,144	43.3	89.45	222,985	32.9
1986	74,377	-25.3	89.45	70,780	-17.3	2006	791,339	16.9	90.14	261,402	17.2
1987	86,880	16.8	88.02	75,313	6.4	2007	936,800	10.5	84.90	338,088	29.3

Source: Saudi Arabia Monetary Agency (SAMA)

*

rate of 7.2% per annum. This expansion was driven by the growth of the Saudi economy under the seventh development plan (2000-2004), which averaged 3.4% per annum. Machinery, equipment and appliances came first, with a share of 21.8% in 2003 and an annual growth rate of 4.7% during 1999–2003. Transportation equipment came next, with a share of 21.2% and an average annual growth rate of 17.8%; followed by food stuffs, with a share of 16.2% and an average annual growth rate of 5.5%, chemical and mineral products were fourth, with a share of 13.7% and an average annual growth rate of 7.5%.

2.5.3 Exports

The Saudi government adopted a trade strategy in order to enhance exports and imports in the country. To promote export strategy, the planners set several objectives which included essential changes in the structure of the balance of payments, reducing foreign reserves while maintaining the value of the Saudi riyal at its current level (i.e. $1=SR3.75), increasing the oil and petrochemicals share in the world market, increasing non-oil export as a proportion of total exports and expanding international economic and trade relations with special emphasis on regional cooperation. Thus Saudi Arabia follows policies that include maintaining the value of the Saudi riyal, supporting export-oriented industries such as petrochemicals, oil refineries and other energy-intensive industries, developing a system of incentives for non-oil exporting industries similar to the existing system of incentives for import substitution industries and enhancing the efficiency of the system of customs tariffs on imports in collaboration with Gulf Cooperation Countries (GCC) states and in line with the World Trade Organisation (Abo dahish 1998).

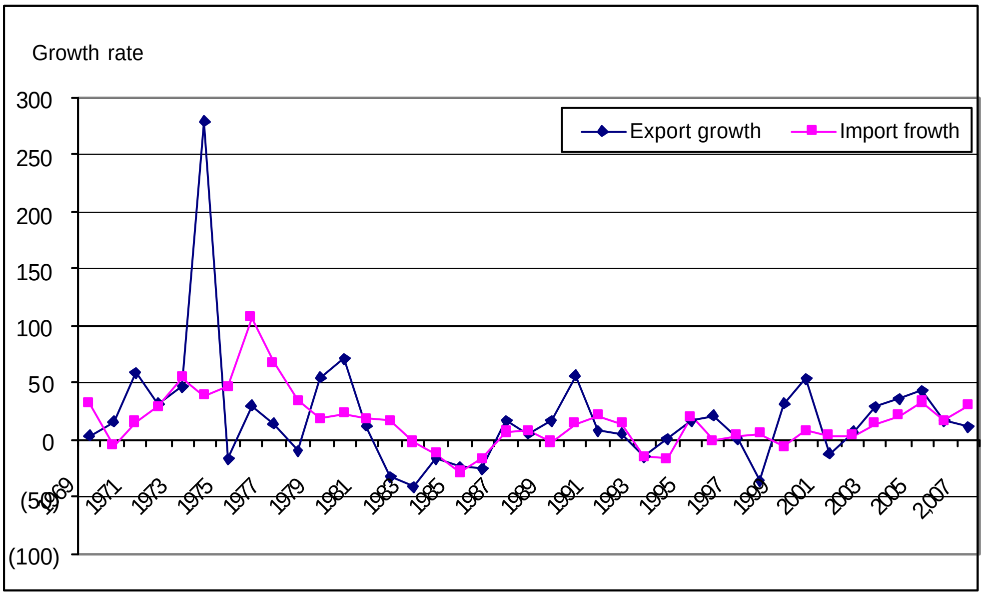
The value of exports rises from SR 9,496 million in 1969 to SR 936,800 million in 2007. In the context of this remarkable progress the value of non-oil commodity exports rose from around SR100.66 million in 1969 to around SR132,034.85 million, in 2007 (Table 2.7).

Crude oil exports constitute the single most important component of Saudi bia's total exports. The share of crude oil in total exports represents above 99% during the 1970s but the share of oil export started decline (98.7%) since 1982 due to increase petrochemicals exports, reaching 82.85% in 1988. Through 1990-93 oil shares registered progress between 90% and 92%. Since then it has steadily declined to reach 83.85% in 1998. In 2000s the share improved ranging between 87.93% and 91.94% (Table 2.7 and Figure 2.7 and Figure 2.8.)

Export commodities can be sorted out by nature into three main groups as shown in Table 2.10, including raw materials; semi-finished products (a material that requires further processing to produce a finished product) and finished products. Raw materials (crude oil) represent a significant portion (about 80%) of total exports during 2004-2007, finished products and semi-finished products represent 8% and 9%.

The importance of export diversification is evident in Saudi Arabia where policy makers attached top priority to achieve a reasonable mix of oil and non-oil exports. Non-oil exports have several benefits including the diversification of sources of national income; sustained GDP growth; more utilisation of domestic natural resources; increased factory utilisation (efficiency); increased local value-added; enhancement of

Figure 2.7 Growth of Imports and Exports



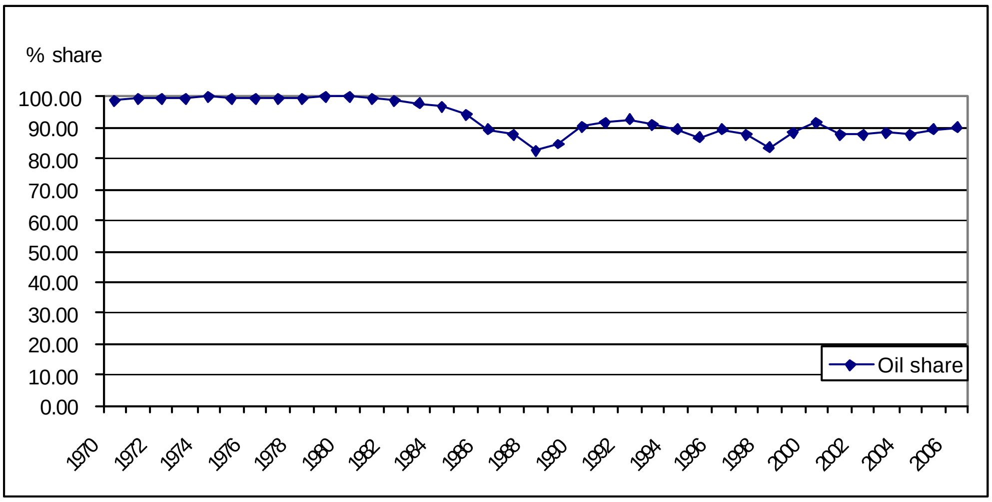
Source: Saudi Arabia Monetary Agency (SAMA)

Table 2.8 Top Ten Country Imports (SR Million)

2003			2007		
Country	Value	% of total	Country	Value	% of total
USA	20780	0.24	USA	51925	0.21
JAPAN	14319	0.16	JAPAN	37316	0.15
GERMANY	12377	0.14	CHINA	35237	0.14
CHINA	8199	0.09	GERMANY	33183	0.13
UK	8125	0.09	S.KOREA	19068	0.08
ITALY	5508	0.06	UK	16951	0.07
S.KOREA	5099	0.06	ITALY	16949	0.07
FRANCE	5062	0.06	INDIA	15223	0.06
INDIA	4093	0.05	FRANCE	13129	0.05
AUSTRALIA	3708	0.04	UAE	9347	0.04
Total	87270			248328	

ource: Central Department of Statistics and Information

Figure 2.8 Crude Oil Share in Total Exports



Source: Saudi Arabia Monetary Agency (SAMA)

Table 2.9 Structure of Imports

Category	Value SR billion		Share (%)		Average annual growth rate
	1999	2003	1999	2003	
Machinery and Equipment	25.19	30.21	24.0	21.8	4.7
Foodstuffs	18.11	22.46	17.3	16.2	5.5
Chemical & Mineral Products	14.22	19.01	13.6	13.7	7.5
Textiles and Clothes	6.49	7.51	6.2	5.4	3.7
Plain Metals & Derivatives	8.81	12.53	8.4	9.1	9.2
Transportation Equipment	15.20	29.29	14.5	21.2	17.8
Leather, Wood and Jewellery	6.37	2.83	6.0	2.1	-18.3
Other Commodities	10.59	14.58	10.0	10.5	8.3
Total Imports	**104.98**	**138.43**	**100.0**	**100.0**	**7.2**

Source: The 8th Development Plan, Ministry of Economy and Planning

Table 2.10 Export by Nature of Item (SR Million)

Discretion	2004	2005	2006	2007
Raw Materials	364889	542077	634390	700676
Semi-Finished Products	39494	51444	59410	70333
Finished Products	68109	83623	97540	103394
Total	472491	677144	791339	874403

Source: Central Department of Statistics and Information

the product quality through competition; growth of the Saudi national employment. (Al-Ali 1997).

The non-oil sector refers to production activity in the manufacturing industry and services through private enterprise, including that segment of the non-oil sector in which government enterprises operate, within the non-oil sector is also subsumed petroleum-related process and other value- added activity. (Al-Sahlawi et al. 2000).

Non-oil export industry and manufacturing now provides employment for some 365,000 people. The Saudi Arabian Basic Industries Corporation (SABIC) expects to produce 48 million tons of basic and intermediate chemicals, polymers, plastics, fertilisers, industrial gases, steel and other metals by 2010[9].

The 44th Annual Report of the Saudi Arabian Monetary Agency (SAMA) showed that Non-oil exports rose by 23.1% annually to reach 7.3% of GDP by the end of 2007. The Plan anticipates diversification of economic activities and sources of national revenue through increased contribution of non-oil sectors to GDP. The value-

[9] http://www.ameinfo.com/110097.html The Ultimate Middle East Business Resource

added of these sectors is expected to increase from approximately SR 525.3 billion in 2004 to around SR 677.2 billion in 2009.

Apparently the government is rapidly diversifying its economy into non-oil sector activity and claims to support this sector for the sake of reducing its dependence on oil.

2.6 Labour Market

Rapid economic growth in Saudi Arabia especially during the periods of increased oil production and oil revenues has resulted in a dramatic increase in demand for foreign workers. This increase in demand for labour is necessary because of the rapidly expanding industrial sector. The main sources of foreign workers include the Arab countries, Southeast Asia and Western countries. The increase in inflow of labour has helped to fill the manpower gap in Saudi Arabia.

However, although a contribution to the country's development, the inflow of foreign workers represents two factors which influence the Saudi economy, increased unemployment in the country, and a flow of workers' remittances to resident households in the countries of origin.

In discussing the unemployment, in 2000 for example, the number of foreign workers was 5.5 million and unemployment among Saudis was 8.15%. The number of Saudis unemployed increased to 6.4 million and this represented the rate of unemployment of 12% in 2005 (SAMA, 2006). Today the country hosts more than eight million foreign workers (GDSI[10], 2010).

The imbalances between supply and demand in the labour market pose challenges that require immediate remedies. The most significant imbalances are:

---

[10] General Department of Statistics & Information

Increased dependency of the national economy on expatriate labour, due to the failure of national manpower to meet increased demand for labour. It is estimated that in 2003 there were about 1.5 expatriate workers to every national worker. This gap emerged as early as the fourth development plan (1985-90) and is now one of the most critical issues to be addressed.

Structural and occupational imbalances in the labour market reflected in the mismatch between outputs of the education and training system and labour market needs. In addition, the types of vacant jobs available and terms of employment fall short of expectations of job seekers.

It is the objective of the eighth development plan (2005-2010) to remedy these imbalances through better control over the quantity and quality of expatriate labour, as well as over the supply and demand sides of the labour market. This would contribute to reducing unemployment ratios, given that a large percentage of unemployment is structural in nature.

The eighth development plan forecasts that the number of employed Saudi national workers would jump from 3.54 million at the beginning of the plan, to 4.75 million workers at the end of the plan. This implies that 1.21 million additional jobs would be made available to the national workforce. Unemployment among nationals stood at 9.6% in 2003 but dropped to 7.04% in 2004 as a result of intensive effort made to employ nationals by the end of the seventh development plan (2000-2005). The eighth plan predicted providing employment to 129,000 job seekers, which would absorb 48.2% of those searching for jobs at the beginning of the plan. The overall objective of the plan is to reduce unemployment among nationals to 2.8% or only

138,900 would remain unemployed by the end of the plan . Unfortunately, this objective was not achieved, unemployment reached 10.5% by the end of 2009 (GDSI, 2010).

With respect the remittance effect, this is worrying given the fact that capital that would have been invested to create more employment opportunities and boost the Saudi economy flows out. According to Money Transfer International (MTI)[11], a global organisation that tracks the flow of funds out of economies, Saudi Arabia ranked number one among the Gulf Council Countries (GCC) in this respect. Other members of the GCC such as United Arab Emirates (UAE) and Kuwait follow Saudi Arabia in that order (MTI, 2008). During the same period the volume of remittances from Saudi Arabia was estimated at SR18.75 billion, placing the Kingdom second only to the US and ahead of Switzerland, which occupied third place.

- **Saudisation Strategy**

Saudisation is a strategy implemented by the government to replace foreign workers with Saudi workers. This program has focused on important targets, including increasing employment opportunities for Saudi nationals in all sectors of the local economy and reducing the flow of funds from the economy.

Through its increased activity in production and investments, the private sector boosted its contribution to employment of national manpower, which increased from about 1.35 million in 1969 to about 6.6 million workers in 2007. Private sector contribution to employment including the oil and gas sector, accounted for about 85.5% of overall employment in the same year compared to around 14.5% in the public sector.

In the past, the adopted policies encouraged citizens to seek employment in the

[11] http://www.btflive.net/news/index.php?news=38163

government sector. As a result of that policy trend, employment of Saudi nationals in the public sector grew at an average of 8.6% per year over the period 1969-1984, compared to a mere 0.56% in the private sector. However, as the government sector reached the saturation level of employment, coupled with the limited job opportunities available to Saudi manpower in that sector, it became essential to increase employment opportunities in the private sector. Furthermore, the sector's participation in building and developing skills has to be ensured. This trend serves to achieve the objectives of Saudization in general and leads to an increased participation of women in economic activities in particular.

Underscoring this role of the private sector, the eighth development plan envisions that some 87.8% of all new job opportunities during the plan period will be provided by the private sector. In addition, Saudi nationals will benefit from job opportunities created by replacing foreign labour with Saudi citizens over the duration of the plan.

In the light of these trends, the level of national manpower in this sector reached about 2.6 million workers in 2007 compared with about 1.2 million in 1984, implying an average annual growth rate of 3.5% over this period. However, attaining Saudisation requires strict enforcement of applicable resolutions and policies, the most important of which are[12]:

- Council of Ministers Resolution 50 of 26/9/1994, which required private sector institutions that employ more than 20 workers to achieve an annual growth rate of Saudi employees of not less than 5% of total employees, and specified the

[12] Five Development Plan, Ministry of Economic and Planning

occupations reserved for Saudis; and Royal Decree 2.T.B/58847 of 17 January 2004, which approved the mechanisms for enforcing this Resolution.

- Council of Manpower Resolution 1/M48/1423 of 2/2/2003 which stipulated that by the end of 2013, expatriate labour and their families shall not exceed 20% of the total Saudi population, and that a balance among nationalities be achieved such that any expatriate nationality shall not exceed 10% of total expatriate residents.
- Decisions that reserve some activities, jobs and occupations for Saudis.
- Decisions and circulars on Saudisation of some trading activities.

The eighth development plan ended in 2009 but the situation shows unsatisfactory performance with respect Saudization program despite the ministry of labor efforts to reduce unemployment of domestic workers. Table 2.11 shows that the unemployment rate fluctuated during the development plan period (2005-2009), it increased from 11.5% (427795 unemployed)) in 2005 to 12% (469018 unemployed) in 2006 then declined to reach 10% (400019 unemployed) in the second half of 2008.

Labor Minister Adel Fakieh estimated the number of unemployed Saudis at 500,000, in 2010, adding that they represent about 10 percent of the expatriate work force. “During the past 15 years, only a few jobs were Saudized,” Fakieh complained, adding that the Saudization program replace less than 10 percent of the foreign manpower with unemployed Saudis (Asharq alawsat news paper, Oct 16, 2010).

Table 2. 11 Unemployees Rate By Sex and Nationality (1999 - 2008)

Year	Total			Saudi		
	Total	Female	Male	Total	Female	Male
1999	4.3	8.1	3.7	8.1	15.8	6.8
2000	4.6	9.3	3.8	8.1	17.6	6.5
2001	4.6	9.1	3.9	8.3	17.3	6.8
2002	5.3	11.5	4.2	9.7	21.7	7.6
2003	5.6	12.5	4.4	10.4	23.2	8.0
2004	5.8	13.4	4.5	11.0	24.4	8.4
2005	6.1	14.1	4.6	11.5	25.4	8.7
2006	6.3	14.7	4.7	12.0	26.3	9.1
2007-1	5.6	13.2	4.2	11.0	24.7	8.3
2007-2	5.8	15.3	4.2	11.2	26.6	8.0
2008-1	5.0	13.0	3.5	9.8	24.9	6.9
2008-2	5.2	14.5	3.6	10.0	26.9	6.8

Source: Central Department of Statistics and Information

2.7 Conclusion

The economic structure of Saudi Arabia is a unique one among developing oil-export based economies. Oil is the main source of income for the government, who is also the owner of all the natural resources. Saudi Arabia's hydrocarbon sector operations are dominated by the state-owned oil company, Saudi ARAMCO, the world's largest oil company in terms of proven reserves and production of hydrocarbons. Thus, the government obtains most of its expenditure revenue from the oil exports via Saudi ARAMCO.

The GDP share by the non-oil sector rose since 1980s. The steady increase in the GDP share of the non-oil sector is an indication of the continuous diversification of the economy. It is, therefore, essential for non-oil public revenues to be enhanced so that oil revenues may be gradually transformed into productive assets and effective human capital.

Expenditure and revenues drive the Saudi economy, which is characterised by a strong linkage between government revenues and expenditures. The government makes its expenditure and revenue decisions simultaneously. That may be attributed to the fact that government depends on its oil revenues which fluctuate over time and in turn affect the government expenditure and the growth of the economy.

Saudi Arabian foreign trade over the past decades witnessed a rapid and significant development reflecting its high economic activity as well as high growth rate. The size and structure of foreign trade are indicators of the level of economic development and competitiveness of an economy. Crude oil plays a vital role in Saudi Arabia. The economy heavily depends on oil production and export. As of today Saudi Arabia is the world leading exporter of oil.

The inflow of foreign workers has increased unemployment among Saudis. It is the objective of the eighth development plan (2005-2009) to remedy these imbalances through better control over the quantity and quality of expatriate labour, as well as over the supply and demand sides of the labour market. Saudisation is a strategy implemented by the government to replace foreign workers by Saudi workers. This program has focused on important targets, including increasing employment opportunities for Saudi nationals in all sectors of the local economy and reducing the flow of funds from the economy.

Chapter 3

Literature on Computable General Equilibrium (CGE)

3.1 Introduction

The Computable General Equilibrium model (CGE) is one of the most popular tools for both research and policy analysis. The basic framework is well known: It is the modern version of Walras' model of the competitive economy (Decaluwe 1988).

3.1.1 What is a Computable General Equilibrium Model (CGE)?

There are number of definitions[13] of a CGE model, a very basic one by Bergman (2003), is a multi-sector model based on real world data of one or several national economies. CGE model is an ideal bridge between economic theory and applied policy research It is intended at quantifying the impact of specific policies on the equilibrium allocation of resources and relative prices of goods and factors. Thissen (1998) defines a CGE model as a fundamental macroeconomic general equilibrium link among incomes of various groups, the pattern of demand, the balance of payments and a multi-sector production structure. Moreover, the model incorporates a set of behavioural equations describing the economic behaviour of the agents identified in the model and the technological and institutional constraints facing them.

In this regard Shoven and Whally (1984) also point out:

> "*The explicit aim of this literature is to convert the Walrasian general equilibrium structure(formalized in the 1950s by Kenneth Arrow, Gerard Debreu and others) from an abstract representation of an economy into*

[13] See for definitions of CGE models also Dixon, Pamenter, Powell and Wilcoxen (1992, p. 70) and Dervis, de Melo and Robinson (1982, p.132-133).

realistic models of actual economies. The idea is to use these models to evaluate policy options by specifying production and demand parameters and incorporating data reflective of real economies". (p.1007)

Dixon (2006) summarises the distinguishing characteristics of computable general equilibrium (CGE) models:

(i) They include explicit specifications of the behaviour of several economic actors (i.e. they are general). Typically they represent households as utility maximisers and companies as profit maximisers or cost minimisers. Through the use of such optimising assumptions they emphasise the role of commodity and factor prices in influencing consumption and production decisions by households and companies. They may also include optimising specifications to describe the behaviour of governments, trade unions, capital creators, importers and exporters.

(ii) They describe how supply and demand decisions made by different economic actors to determine the prices of at least some commodities and factors. For each commodity and factor they include equations ensuring that prices adjust so that demand added across all actors does not exceed total supply. That is, they employ market equilibrium assumptions.

(iii) They produce numerical results (i.e. they are computable). The coefficients and parameters in their equations are evaluated by reference to a numerical database. The central core of the database of a CGE model is usually a set of input-output accounts showing for a given year the flows of commodities and factors between industries, households, governments, importers and exporters. The input-output data are normally supplemented by numerical estimates of various elasticity parameters. These may include substitution elasticities between different inputs to production processes, estimates of price and income elasticities of demand by households for different commodities, and foreign elasticities of demand for exported products.

An alternative name for CGE models is applied general equilibrium (AGE) models. This name emphasises the idea that in CGE modelling the database and numerical results are intended to be more than merely illustrative. CGE models use data for actual countries or regions and produce numerical results relating to specific real-world situations.

Since 1960 computable general equilibrium (CGE) modelling has gradually become the dominant economy-wide framework, largely replacing other approaches such as input-output modelling and economy-wide econometric modelling. CGE models have a solid data basis since they are calibrated to reproduce national accounts information. Those models also heavily rely on microeconomic theory, which justifies the use of CGE models for policy support. It has become more widely used for policy and shocks analysis in developing as well as developed countries. The model's applications have focused on microeconomics and macroeconomics for short and long term issues.

The basic theoretical framework of CGE models is the Walras' model of the competitive economy. As such, only relative prices matter, producers maximise their profits, consumer maximises his utility. The model's solution provides a set of prices, which clears all markets simultaneously.

3.1.2 History of CGE Models

The CGE model has a long history of progress starting from Leontief when he published his input-output model in 1937 for the US until the early 1970s. Dervis et. al. (1982), argue that extensions and developments of Leontief input-output led to the relations among sectors which in turn made more complex analytic and ultimately general equilibrium introduced in a variety of practical applications.

The first serious attempt to use a large CGE model to study a real economy appears to be Leif Johansen's who formulated the first empirically based, multi-sectoral study of economic growth (MSG) for Norwegian economy (1961). He uses twenty production sectors and one aggregated household sector, estimates the impact of exogenous factors (consumption, investment and export) on the Norwegian economy. Johansen in his model developed an input-output model adopting Walrasian general equilibrium theory, he keeps the fixed input coefficients for intermediate input and value added production functions and factor markets where market-clearing prices for labour and capital. This model became an essential research tool in Norway and had an important role for the ORANI[14] model of Australia, and on the design of CGE models of developing countries. (ORANI is a large-scale multi-sectoral model of the Australian economy. The ORANI model provides considerable detail on individual industries within an economy-wide framework). Arnold Harberger (1962), is the first person investigated tax policy questions numerically in a two-sector general equilibrium frame work.

The breakthrough was the introduction of an algorithm for the solution of the general equilibrium problem of a Walrasian system that is, for the computation of

[14] For more details about ORANI model see A Guide to the IAC's use of the ORANI model, Information paper, December 1987

equilibrium prices which was developed by Hebert Scarf (1967). This first algorithm model paved the way for the development of applied general equilibrium models, by providing researchers with a solution method with fewer restrictions. The first fully disaggregated CGE model was introduced by Shoven and Whalley (1972) to evaluate the effects of differential taxation of income from capital in the United States.

After the efforts of Dale W. Jorgenson in 1974, the extension in his model was that supply and demand is estimated with simple calibration techniques. It was a distinctive contribution to CGE especially to production, and national accounting. Jorgenson's dynamic models have been used for analyses of the welfare effects of taxations types.

Subsequently the number of CGE models of national economies exploded. The work of Dervis, de Melo and Robinson (1982) represents a substantial advance in formulation of computable general equilibrium models and their application to the policy of countries. Shoven and Whalley (1984) have addressed policy issues in the areas of tax and international trade, following the tradition of the earlier analytical models.

Finally and maybe the most important point, CGE development has shifted from static to dynamic models. An example was achieved by Bergman (1983), he addresses both static and dynamic models in the same time using Swedish data. However, accessibility of CGE modelling has been enhanced by the development of user-friendly software.

The introduction of General Algebraic Modeling System, ((GAMS) (Brooke et. al. 1988)), was a key advance in CGE modelling which meant that you do not have to be an expert to quickly deal with the relatively large number of parameters. Literally the development of CGE modelling would not have been possible without the dramatic development of fast computers and suitable software.

There are three main areas where the applications of CGE models are concentrated: a) trade, b) taxation, and c) energy/environment. Iqbal and Siddiqui (2001) refer to different studies on CGE models carried out in different areas including taxation and trade; studies related to dynamic CGE modelling of national tax issues, the contribution of CGE models to quantification of trade policy scenarios in developing countries; country specific economic structures of production, private consumption, external trade blocks, and types of closure rules; development policies in LDCs; micro-macro CGE models that incorporate asset markets and product and factor markets; models which compared the regional CGE approach to input-output analysis and regional issues; examine regional economies and regional policy issues. Among other areas explored are, issues of public finance and taxes, international trade policies and tariffs, regional development, energy. Also employment, income distribution, social welfare, industries, education, training and environmental policies have been addressed in the context of CGE framework. A substantial number of CGE models were constructed for the developing countries.

3.1.3 A Literature Survey of CGE Models

A number of authors were focusing on surveying the CGE models. For example, Decaluwe (1988) reviews 73 applications of CGE models to 26 different developing countries. The emphasis is on the economic structure and the policy simulations of the model. These countries vary greatly in terms of standard of living, degree of industrialisation, relative openness to external trade, importance of the public sector, and nature of the policies pursed. Excluded from the survey are world CGE models where developing countries appear as one aggregated region or as set geographical sub regions.

Shoven and Whalley (1988) also surveyed general equilibrium modelling applied to tax and trade policy. They focused on measures of the efficiency and distributional impact of tax and trade liberalisation policies. Devarajan (1988) surveyed energy CGE models and their applications.

Pereira and Shoven (1988) survey 11 models that include at least some dynamics in their structure. It treats the issue of incorporating dynamics into the model, and also discusses different computational and implementation approaches. Finally, it includes a dynamic computational general equilibrium model of corporate tax integration that indicates the potential importance of modelling dynamic choices.

De Melo (1988), surveys the contributions of computable general equilibrium (CGE) simulation models designed to quantify the implications of alternative trade policy scenarios in developing countries. The study starts with a review of the basic structure of CGE models, using a one-sector model with product differentiation on the import and export side. The basic properties of CGE models are established and a series of applications to trade policy, internal-external balance and growth, and inter-temporal issues are discussed.

A survey of relevant simulation results for energy policy issues have been done by Bergman (1988), the CGE models have been used in the energy sector. He points out that public concern about the economic impact of changing energy supply conditions has induced the development of energy-economy models based essentially on general equilibrium theory and the neoclassica1 theory of economic growth. These models are capable of explaining the adjustment of energy consumption, through changes in factor proportions and sectoral output levels, resulting from changing energy prices. Subhe (1996) reviews the literature on such general equilibrium models as applied to energy studies, and reports their features, evolution through time as well as their limitations. Adkins and Garbaccio (1999) have set up a bibliography represents an attempt to assemble something of a comprehensive accounting of the application of computable general equilibrium (CGE) models to the analysis of environment related issues.

3.1.4 General Information about CGE Models

3.1.4.1 CGE Application to Oil Exogenous Shocks and Fiscal Policy

CGE models are commonly used to assess the economic consequences of shocks or policies, such as oil demand and oil prices shocks or trade, environmental policies etc.

i. CGE Models and Oil Exogenous Shock

One of the identifiable sources of shocks that have attracted the attention of many economies is oil price shocks. The effects of these shocks on the economies have been widely recognised in the literature.

Pradhan and Sahoo (2000) construct a 23-sectors, 3-factors and 9-households groups Computable General Equilibrium (CGE) model to analyse the impact of international oil price shock on the welfare and poverty of socio-economic household groups in India. The external shocks affect the welfare and poverty of households directly as well as indirectly. Oil shock leads to decline in household welfare and increase in poverty. With the increase in elasticity of substitution of demand for imports to domestically produced crude oil, welfare loss for household groups goes on increasing.

De Miguel, Carlos et al. (2003) analyse the effects of oil shocks on the features of the business cycle and on welfare in the context of a small open economy such as is the case of the Spanish economy. The model used for this analysis is based on the standered dynamic general equilibrium model for a small open economy in which oil is included as an imported productive input. The price of oil as well as the interest rate is assumed to be set by the international markets. The results show the ability of the model reproduces the cyclical path of Spanish economy, especially in those periods when oil price shocks were most dramatic. This kind of shock accounts for more than half the size of the aggregate fluctuations of the economy. In addition, the model reproduces other regularities of the business cycle. Finally, they have shown that the increase in the relative price of oil had a negative and significant effect on welfare.

Doroodian and Boyd (2003) examine whether oil price shocks are inflationary in the US using a dynamic computable general equilibrium (CGE) model. The results suggest that while a shock of the magnitude experienced in the 1970s will have a fairly severe effect on such things as gasoline and refinery prices, the aggregate price changes will be largely dissipated over time at the aggregate level. Furthermore, the aggregate level of prices (CPI and PPI) will fall over time as the level of technological advances.

In the context of oil price shocks, Benjamin et al. (1989) applied CGE model to analyse the impact of booming oil or so called "Dutch Disease" on a developing country, Cameroon. Among the conclusion of the paper are that (i) the agriculture sector is hurt most by the oil boom and (ii) the traded goods sector as a whole contracts and, some sectors expand due to their imperfect substitutability with foreign goods, (iii) the gap between rural and urban income widens, although there is a real wage rise across the board.

De Santis (2003) attempts to explain the impact of crude oil supply and demand shocks on prices, output, profits and welfare in Saudi Arabia using a CGE model. The results support the view that any shock in the oil market has an overshooting effect on oil prices, whereas output moves steadily towards the long term equilibrium. The negative demand shock affects the crude oil market, the difficulties faced by Saudi Arabia are both grave and significant. Therefore, Saudi Arabia has an incentive to cut production in order to sustain higher prices. By contrast, if a positive demand shock affects the market, the large gains do not encourage Saudi Arabia to expand production. Any supply shock has an adverse effect on Saudi welfare, which suggests that Saudi Arabia would avoid any intervention which might disturb the equilibrium in the crude oil market.

Descamps, Patricia et al. (2005) analyse and model the effects of macroeconomic shocks on poverty and income inequality in Venezuela. They carry out five simulations combining two macroeconomic shocks: a terms of trade shock (price of oil) and a fiscal shock. They find that both shocks generate considerable income volatility, especially in poorer households. They also find that the most important transmission mechanism of simulated shocks is through labour income. Finally, a sharp increase in government expenditure generates negative net effects on household income one period after policy implementation, due to the consequences of growing fiscal imbalances.

Yang, Chin-Wen et al. (2006) examine how the technology adoption decision may change under given world crude oil price shocks in Taiwan. The results indicate that significant changes in technology adoption decision shall occur under given world crude oil price shocks. When import energies become more and more expensive, renewable energy generators will become profitable and will eventually be installed. However, when oil prices increase, energy demand will also be cut, which might cause the time of adoption and expansion of renewable energy generators to become longer.

Coffman, Makena (2008), using a computable general equilibrium model for Hawaii, simulates doubling the world price of oil, showing macro, sector, and consumer welfare changes. The model findings support the oil price-macro economy relationship found within the literature, namely that a 100% oil price shock decreases real productivity (- 3.7%), decreases real wages (- 1.3%), and is overall inflationary (1.3%). The model's ability to show both decreased output and decreased real wages shows the strength of general equilibrium analysis in explaining consumer and producer interaction. At the sector level, the petroleum manufacturing industry constrains real output as a result of the rising input price of oil. It passes along a large portion of the price burden, increasing nominal output by 20%, the price of electricity in Hawaii has risen by 39%.

ii. CGE Models and Trade Liberalisation

Go (1994) using a dynamic CGE model framework, examines the sensitivity of investment and growth to external shocks and adjustment policies. The study highlights the inter-temporal trade-offs of tariff reform, a policy often recommended in the 1980s, emphasising the need for complementary measures to ease macro imbalances and short-term dislocations of the protected sector. He finds that a package of policies, consisting of a reform of domestic taxes and incentive schemes, combined with a tariff reform, is ideal during an import price shock.

Feraboli and Trimborn (2008), apply a CGE model to Jordan to investigate the economic implications of introducing trade liberalisation on aggregate economic performance as well as effects on welfare and income distribution of heterogeneous households. They conclude that trade liberalisation alone is not pareto improving for Jordan. In addition, they found contrary effects concerning welfare and income distribution. While on the one hand welfare gains are slightly higher for low income households, on the other hand the gap in income will increase, especially in the long-run.

Acharya and Cohenb (2008) examine the impact of trade liberalisation on household welfare using a CGE model. They modify the standard neo-classical model and apply it to a typical South Asian village economy. Liberalisation under a flexible exchange rate regime when compared to the fixed regime can work negatively since the currency may appreciate much and eliminate the comparative advantages. They also find that a piece by piece external reform gives better economic results than implementing all external reforms together.

Carneiro and Arbache (2008) examine the impacts of trade liberalisation on macroeconomic variables and labour market indicators in Brazil. The discussion comes out of an earlier debate on the role of trade liberalisation in shaping labour market outcomes in the well-known Heckscher–Ohlin and Stolper–Samuelson (HOS) theorems. To address these issues, they use a computable general equilibrium (CGE) modelling approach to model the patterns of export growth by sector and their effects on macroeconomic and labour market indicators. Overall the results show that trade liberalisation contributes to improve economic welfare by means of greater output, lower domestic prices, and higher labour demand. The benefits of this economic improvement tend however, to be appropriated by the most skilled workers in the most trade-oriented sectors, contradicting the predictions of the HOS theorems.

Dominguesa, Edson et al. (2008), use Applied General Equilibrium (AGE) to assess the welfare results of alternative free trade areas (FTA) for three countries, Brazil, Argentina and Uruguay. It is shown that welfare gains for Brazil are very robust to different degrees of trade liberalisation, and allocation effects drive these gains. For Argentina and Uruguay, welfare gains depend heavily on a higher degree of liberalisation, as they are connected to terms of trade effects. The study shows that trade elasticities are important parameters driving the model's results, as welfare gains for Argentina and Uruguay in both scenarios are very sensitive to these parameters.

Konan, Denise and Maskus, Keith (2000), develop a CGE model of the Egyptian economy to analyse the impact of various trade liberalisation scenarios, allowing distortionary domestic taxes to vary endogenously in order to satisfy a fixed real government revenue target. The results indicate that both trade and tax distortions are important and that they interact in determining the efficiency costs of revenue-generating policies. Various policy combinations may also redistribute income via effects on real factor prices.

Finally, Al-Thumairi (2006) uses a dynamic CGE model to examine effects of the Saudi fiscal reform plan. She carried out three policy scenarios. The first is increasing government saving by 5% and financing it by increasing household tax. The second is an increase of government saving by 5% and imposing a 5% value added tax on domestic and imported products. The final scenario increases government saving by 5% and imposes a 5% sale tax rate. They all aim to diversify government revenue.

She concludes that the overall growth performance of the economy from direct income tax scenario is positive. Total absorption and real household consumption are improved at a very small rate. This is achieved mainly through the mechanism derived from increasing direct government transfers to households. Introducing other forms of taxes can, in principle, raise government revenues without causing major distortions. The least negative impact on current real household consumption is from sales tax scenario where it generates revenues with minor impact on incentives. A broad-based VAT scheme has negative effects on the overall growth performance of the economy.

In conclusion, the CGE models, dynamic or static are applied broadly in different fields to investigate the effects of exogenous shocks or fiscal policies on economy performance because of advantages the models possess. The next subsection summarises the advantages of CGE models.

3.1.4.2 Advantages of CGE models

Computable general equilibrium models have achieved a high degree of success because of their advantages[15]. They are appropriate for analysing various policy changes and external shocks which cannot be done by partial equilibrium or econometric models because of unavailable reliable data for a long period,

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[15] For more detail in terms of the advantages of CGE see Dervis , de Melo and Robinson (1982); Bergman(2003); Pereira and Shoven (1988).

inconsistency of available data and frequent changes in policy that require various structural models (de Melo,1988). Some economists consider CGE models as "black boxes" which may generate any solution but the theoretical foundation of such models makes it possible to trace back the simulation results and determine which factors are important in explaining them. The CGE model allows a study of different impacts across sectors of production and across consumer groups. Also, it allows a consideration of the interactions among different sectors and agents. The CGE methodology uses flexible computational numerical techniques. The flexibility of the solution algorithms has made possible the development of disaggregated models, which also contributes to their practical usefulness. Another factor contributing to the attractiveness of general equilibrium approach for certain types of studies is the fact that they are solved numerically and not analytically

These models have the advantage of taking into account the economic flows in a flexible manner, the specifications can be changed according to the analytical needs. Similarly one can pick and choose amongst the choice of closure rules for these models. Unlike the other forms of economy-wide modelling (such as a simple I-O model) a CGE model can incorporate explicitly the price effects and probably the most important feature is that these models are strongly founded in microeconomic theory.

Furthermore, CGE models are suitable for analysing large regime shifts policy involve substantial changes such as eliminating tariff or such as eliminating tariffs or adopting new technologies new technology.

This approach can be used to analyse many policy changes simultaneously to capture their combined effects.

A final advantage of general equilibrium models which may be important for policy analysis is the possibility of deriving better measures of the welfare gain or loss associated with a new policy. In particular, welfare measures related with these models help explain how the situation of a consumer or group of consumers has changed, what factors contributed to improve or worsen it and what the relative weight of each one is.

3.1.4.3 Policy Classification of CGE Models

The CGE models can be classified in different ways: one approach is the classifying of models according to the policy applied. CGE models can also be classified as developed and developing country CGE models, or as single and multi-country CGE models or static and dynamic CGE models[16].

Policy Classification:

Computable general equilibrium models can be classified by feature of policies or issues they handle. Economists have used CGE models to study income distribution effects as well as for simulating international trade policy. They have used some applications to evaluate tax policies and also to evaluate oil price effects and energy policy. CGE models have the feature of capturing most of the interactions of the different actors in the economy and hence, they are useful to analyse a wider range of policies efficiently.

- **Developed and Developing Countries**

There are a number of models that focus on issues that are more relevant to

[16] For more detail see Dervis, de Melo and Robinson, (1982); Bergman (2003); Shoven and Whalley (1984); Robinson (1988) and Bandara (1991).

developed countries and also a number of models that are more relevant to developing countries. Where some of them reflect the characteristics and policy issues in developed countries others capture the special characteristics and policy issues in developing countries.

In the past, the CGE models designed for the developed countries were mainly neoclassical. They were based on the hypothesis of optimising agents and full labour employment and capacity utilisation. They evolved from the general equilibrium framework of Walras and the work on the numerical solution of a Walrasian system, by Scarf (1967).

De Melo (1988) points out that the use of computable general equilibrium models for policy analysis has become widespread for both developed and developing economies. For developed economies, with a few notable exceptions, applications have focused on microeconomics with the analysis concentrating on estimating the welfare impact of alternative tax structures or energy policies. In developing countries CGE models have been used for a wider range of issues, from medium to long-term macroeconomic policy analysis to the more traditional microeconomic issues analysed in developed countries as well. Pereira and Shoven (1988) review 73 applications of CGE models to 26 different developing countries. The emphasis is on the economic structure and the policy simulations of the models. These countries vary greatly in terms of standard of living, degree of industrialisation, relative openness to external trade, importance of the public sector, and nature of the policies pursued.

- **Single and Multi-Region**

Brianes et al. (2006) argue that regional CGEs are naturally suited to examine geographical features of economic activity, which are crucial considerations on the speed and spread of economic development. These features include factor mobility, market integration, as well as transport and transaction cost. Regional CGEs may be used to geographically disaggregate the impact of economy wide policies, e.g examination of regional tax incidence. Furthermore, regional CGE models can examine regional development and welfare policies, such as geographically targeted transfers, location-based industrial incentives, and public investment allocation.

Some CGE models are single-country types designed to investigate how developments abroad affect individual economic. Others are multi-country models which typically cover a region, such as the European Union and consists of sub-models of each of the countries within that region. The model can be designed to analyse global issues such as the volume and direction of trade and their impact on particular regions. Multi-country CGE models focus on the evaluation of tariff reductions and economic integration issues. However, single-country models tend to be more detailed in terms of sectors and household types, and they are in general used for analysis of country-specific policy issues and proposals. Multi-country and global models on the other hand tend to have less sector detail and to be designed for analysis of proposed multi-lateral policies such as free-trade agreements.

There are some distinctions between multi-regional CGE models and single regional CGE models, in addtion to same characteristics to single regional CGE models. The distinctive features of multi-regional CGE models may be concluded as follows: (1) Each region should be modelled separately as an individual economy. The model contains region-specific prices, region-specific industries, region-specific consumers, and so on. Based on region-specific modelling, regional differences can be depicted. (2) The model should reflect economic linkages and interactions across regions, such as interregional commodity flow, labour flow and capital flows and so on. Based on description of these linkages of economic activities across regions the impacts of one region on other regions can be analysed.

- **Dynamic and Static CGE Models**

CGE models can be static or dynamic. The static CGE is a model run for one period while the dynamic model is run for several periods. The magnitude of the effects in a static model are small compared to the dynamic effects. The inter-sectoral effects are immediately exhausted in a static CGE model while these are amplified in the dynamic version.

3.1.5 Conclusion

The CGE model is the modern version of Walras' model of the competitive economy.(Decaluwe 1988). Since 1960 computable general equilibrium (CGE) modelling has gradually become the dominant economy-wide framework, largely replacing other approaches. The CGE model has a long history of progress starting from Leontief when he published his input-output model for the US in 1937 until the early 1970s. The first serious attempt to use a large CGE model to study a real economy appears to be Leif Johansen's who formulated the first empirically based, multi-sectoral study of economic growth for Norwegian economy (1961). Subsequently, the number of CGE models of national economies exploded. There are three main areas where the applications of CGE models are concentrated: trade, taxation, and energy/environment. Lofgren et al. (2002) built the standard structure of the CGE model. The standard CGE model explains all of the payments recorded in the SAM. The model therefore follows the SAM desegregation of factors, activities, commodities, and institutions. However, CGE models have achieved a high degree of success because of their advantages being analysing various policy changes and external shocks. Some economists consider CGE models as "black boxes" which may generate any solution, in addition the flexibility of the solution algorithms.

Finally, the CGE models can be classified in different ways: applied; developed and developing countries ; single and multi-country or static and dynamic CGE models.

Chapter 4
Social Accounting Matrix (SAM)

4.1 Introduction

There is a continuing need to use recent and consistent multi-sectoral economic data to support policy analysis and the development of economy-wide models. A Social Accounting Matrix (SAM) provides the underlying data framework for this type of model and analysis. A SAM includes both input-output and national income and product accounts in a consistent framework. (Robinson et al 2001)

The development of the SAM has gone through different stages. The first work was by Kuznets (1937) on national income accounts, and Leontief (1941) on input-output matrices. Meade and Stone (1941) developed the first logically complete set of double-entry national income accounts. Subsequent work was carried out by Stone (1947). The development of social accounting went hand-in-hand with the development of planning models that used this data. The significant work by Pyatt and his co-authors since 1976 have developed SAM models to be a simple and practical tool especially in CGE models

4.2 What is a SAM?

A SAM is a square matrix consisting of rows and columns that represent the different sectors, agents, and institutions of an economy at the desired level of disaggregating. By convention each account in the SAM is represented by one row and one column of the table. To attain the balance in any account, total revenue (row total) must equal total expenditure (column total) for each account in the SAM. The number of transactions, called accounts, constitute the diminution of the square matrix. A SAM is a useful framework for preparing consistent, multicultural, economic data that integrates national income, input-output, flow-of-funds, and foreign trade statistic into a comprehensive and consistent data set.

The SAM is a consistent and complete data system that captures the interdependence that exists within a socio-economic system. It includes both the IO and national accounts and product accounts in a consistent framework. It is a comprehensive, flexible, and disaggregated framework that elaborates and articulates the generation of income by activities of production and the distribution and redistribution of income between social and institutional groups. (Round, 2003).

Most often the data in a social accounting matrix (SAM) are used to implement empirical multi-sectoral and computable general equilibrium (CGE) models, which are in turn used to perform economic analyses and policy simulations. (Cardenete and Sancho, 2004).

In a SAM framework every agent's expenditure has to equal its receipt (in the form of equality between column and row sum), so that the SAM explicitly represents the initial equilibrium, or market clearing conditions in the economy. Every good and service produced by industry is equal to what is demanded. Each factor of production supplied has to be absorbed by industry, and household spending has to be equal to income. An exercise using a CGE model is basically comparing this initial equilibrium condition with other equilibrium induced by changing exogenous shocks to the model. A SAM can be seen as a baseline measurement of the general equilibrium interactions in the economy for a particular year. (Braber et al, 1996).

It is well known that accounts for transactions within an economy can be presented in a matrix as well as a double entry format. Such a matrix is known as a social accounting matrix (SAM) and must be square. Within it each row records the details of receipts by each particular account, the columns (which follow the same ordering as the rows) record the corresponding expenditures. Thus the entry in row i, column j, represents receipts by account i from account j or, alternatively, expenditures by account j that are paid to account i. Within such a general schema SAMs can take a wide variety of forms, depending on how the constituent accounts are defined. (Pyatt and Round, 1985)

A SAM has several advantages. First it gives a clear picture of the economic, social and financial structures of an economy. Second, it serves as an input for static and general equilibrium modelling and simulating the effects of policy (or events) on an economy. Third, it eliminates any data inconsistencies existing among different sources of data. (Sen, 1996).

The main features including: First, the accounts are represented as a square matrix; where the incomings and outgoings for each account are shown as a corresponding row and column of the matrix. The transactions are shown in the cells, so the matrix displays the interconnections between agents in an explicit way. Second, it is comprehensive, because it represents all the economic activities of the system (consumption, production, accumulation and distribution) although not necessarily in equivalent detail. Thirdly, the SAM is flexible in that, although it is usually set up in a standard, basic framework there is a large measure of flexibility both in the degree of disaggregation and in the emphasis placed on different parts of the economic system. (Goce-Dakila and Dakila Jr, 2004).

Once a SAM for a particular year is constructed it can be used as a database for initialising CGE models. By using the calibration approach, most of the parameters of a CGE model are directly derived from the SAM (Chung-I Li, 2002) while some other parameters, usually elasticities of substitution, are taken from other sources. The calibration procedure is further explained in Chapter 4.

4.3 Difference between SAM and Input-Output (IO)

A clear distinction must be made between the IO table and the SAM. The essence of the IO table is the way industries are interrelated through transactions, while the SAM also presents the transactions and the transfers between the different types of economic agents like households, various categories of companies, government and the rest of the world (Pyatt, 1999).

The terminology in a social accounting framework is somewhat different than that of an input-output model and bears review. The typical term for payments to workers and profits is value-added. In a SAM framework, we refer to value-added as payments to factors of production. The consumption of goods and services by households, government, and capital are usually call final demands in an IO framework. In a SAM framework, the consuming final demand sectors are called institutions, hence the term inter-institutional transfers.

Input-output accounts capture inter-industry relationships through flows of intermediate inputs between different sectors, i.e., representing the production technology of each economic activity. It also gives a summary of value added accruing to each activity and finally provides information on the structure of final demand (private consumption, government expenditures, investments, exports and imports.) (Chulu and Wobst , 2001).

A SAM can be used for macroeconomic planning in two ways: first, a SAM can provide a framework for the organisation of information related to economic and social structures of a country's economy. Second, a SAM can serve as a database for a model of the economy under consideration.

On the other hand, a SAM disaggregates the macroeconomic (national) accounts and links these with the economy's input-output accounts. The SAM is thus an expansion of input-output accounts incorporating more disaggregated details of factors and institutions, such as the various types of labour and households. Thereby, it provides an economy wide perspective of all macroeconomic, sectoral and institutional transactions in a fully consistent framework. In fact, SAMs can be viewed as a straightforward extension of input-output tables in that they capture the distribution of income in addition to production and demand and thereby close the income circle. (Thiele and Piazolo, 2003).

4.4 Social Accounting Matrix for Saudi Arabia

For Saudi Arabia, the SAM is an extremely valuable tool providing a model that can help policy makers think systematically about what kind of future they want and what actions to take today in order to achieve that future. As an economy-wide model the SAM provides a concrete basis for moving away from sectoral planning to integrated, economy-wide planning. We distinguish two disaggregate type of SAMs. The first type of SAM is the disaggregated Micro SAM (24 sectors). It disaggregates most of the Macro SAM accounts with respect to desired sectoral and institutional breakdowns. The second is less disaggregating SAM (8 sectors) or aggregated from the previous version. The next subsection describes the Saudi 2000 micro (disaggregate)

SAM.

4.4.1 Disaggregate SAM for Saudi Arabia

The main interest in using a SAM is to engage in further disaggregating of certain accounts in the macro system and to estimate the transactions in more detail. Thus the SAM evolves from being a macro SAM to become a micro framework. It records consistent and sometimes quite detailed sets of transactions and transfers between different kinds of agents often interacting through different markets, especially the commodity and factor markets.

The first SAM was constructed for Saudi Arabia is the disaggregate 1990 (15x15) SAM for the Saudi Arabian economy by Haji (1993). The activities and commodities were disaggregated into nine different sectors. He used that SAM in his studies and then it has been used by others. De Santis (2003) in his study "Crude oil price fluctuations and Saudi Arabia's behaviour" relied on the Haji SAM (1993) for Saudi Arabia. He applied it to the same sectors but with a little adjustment by adding up the entries on the capital column to the investment column.

Chemingui (2004) built his disaggregate 2000 SAM for Saudi Arabia in order to analyse the impact of reducing tariff rates and introducing a different tax structure on the economy of Saudi Arabia using a general equilibrium model. The activities and commodities disaggregated into 24 different types. The CGE model is based on a more detailed SAM, with disaggregation of activities, commodities, factors, and domestic non-government institutions and a macro savings-investment account (S-I). The rest of the world is also an actor, buying exports, selling imports, and providing and receiving transfers and factor income.

Table 4.1 derived from the disaggregate SAM provides information about the sectoral structural of value added, output, and trade. Oil represents 39.9% of total value added and the second largest sector, real estate and related services, represents 8.9%, followed by government services (which only accounts for part of the public sector) with 7.5%. Imports are connected in other manufacturing products (33.5% of total imports) followed by textiles, wearing apparels and leather industries (12.6 of total imports). Exports are concentrated on crude petroleum and natural gas (78% of total exports), petroleum refining (11.3%) and other chemical products (5.6%) Chemingui et al. (2004). CGE model will be applied in this study and less disaggregate SAM will be carried out in order to suite the objective of the study. The following sub-section describes the new disaggregate SAM for Saudi Arabia.

4.4.2 New Disaggregate SAM 2000 for Saudi Arabia

This SAM adopts Chemingui's SAM (2000) for Saudi Arabia which is a disaggregate SAM, but since the model that I use focuses on macro variables more than micros I reduce it to kind of aggregate SAM. For example, agriculture, hunting, forestry and fishing sectors are located under the Ministry of Agriculture, so I add them up to one sector (Agriculture). Another example, oil and mining supervised by the Ministry of Petroleum and Mining, they are collapsed into one sector (Crude oil).etc.

The 24 activities and 24 commodities are collapsed into 8 activities and 8 commodities. In other word the input-output table of 24x24 for 2000 SAM reduced in this SAM to matrix of 8x8. Table 4.2 shows codes, definitions of disaggregate SAM (24 sectors) and less disaggregate SAM (8 sectors).

This new SAM[17] distinguishes the following accounts: activities, commodities, factors, households, taxes, savings-investment, and the rest of the world. Activity column entries indicate expenditures incurred during the production process and include purchases of intermediate inputs and payments to the factors of production. The total supply of commodities, value at market prices, is given as domestic marketed production, imports of goods and services, The commodity row gives the total demand for marketed commodities and includes household and government consumption. Furthermore, factors include labour and capital. The factor account factors payments to the households. Household column indicates the allocation of total household income among indirect taxes, savings and ROW. In addition, the savings-investment column gives the total investment expenditure in the economy, while the ROW column shows the exports of goods and services. Purchases of imports and receipts of factor payments are specified in the row.

In general, the SAM provides a snapshot of the economy at a single point in time and each cell records the value of each transaction (i.e. the product of prices and quantities).

The classifications of new accounts in the new SAM are as follows:

The agriculture, hunting, forestry and fishing sectors are collapsed into one sector namely agriculture and takes the code (AGRI); crude petroleum and natural gas changed to crude oil (CRDO); petroleum refining to refinery (REFI); other mining and quarrying, basic metal industries, fabricated metal products, machinery and equipment, other manufacturing industries, wholesale, retail trade, repair of motor vehicles and

[17] Table of SAM is attached in appendix 5

personal household good, food, beverages, tobacco, textiles, wearing apparels and leather industries, wood, wood products and furniture, paper products, printing and publishing, other chemical products (except petroleum refining) added up to manufacture sector (MANF); electricity, gas, and water supply to utility sector (UTIL); transport, storage, communications, financial institutions, real estate, renting, business activities, public administration, defense, compulsory social security, hotels, restaurants, other community, social, personal activity, wholesale, retail trade, repair of motor vehicles, personal household good to trade service sector (TRDS); education, health, social work, private households with persons employed to non-trade service sector (NTRDS). The rest of sectors are not changed: Saudi labour (SLAB), non-Saudi labour (NSLAB), indirect tax (INDTAX), government (GOV), savings-investments (S-I), import tax (IPMTAX), construction (CONST) and rest of the world (ROW).

Table 4.1 shows the structure of Saudi economy in 2000. Table 4.2 displays 2000 (IO) and the modified disaggregate 2000 SAM of Saudi Arabia. The final modified SAM 2000 for this model is in appendix 5. Next, each account in the modified SAM will be discussed in detail.

Activity/commodity

The production of goods and the supply of commodities to domestic and export markets make up a big part of this SAM. The production sector accounts are disaggregated in the same way as the commodities account, distinguishing 8 activities. There are eight activity sectors (rows 1-8), and eight commodity sectors (rows 9-16) namely agriculture, crude oil, refinery, utility, manufacture, construction, trade sector and non-trade sector.

Table 4. 1 Economic Structure for Saudi Arabia in 2000 as Percentage of Total (%)

	Value added (VA)	Output (X)	Exports (E)	Export/ Output (E/X)	Imports (M)	Import/final Demand (M/Q)
Agriculture, hunting and forestry	4.9	4.3	0.1	0.5	3.7	14.8
Fishing	0.2	0.2	0.0	0.0	0.0	0.0
Crude petroleum and natural gas	36.9	25.8	78.0	82.9	0.0	0.0
Other mining and quarrying	0.4	0.3	0.0	4.1	0.5	80.2
Petroleum refining	3.0	5.0	11.3	62.1	0.0	2.0
Food, beverages and tobacco	0.2	1.5	0.6	11.1	0.1	58.6
Textile, wearing apparels and industries	0.3	0.3	0.2	15.9	12.6	80.7
Wood, wood products and furniture	0.2	0.3	0.0	0.0	4.7	68.1
Paper products, printing and publishing	0.3	0.5	0.2	11.6	2.2	21.2
Other chemical products (except petroleum refining)	5.6	7.5	5.6	20.4	0.4	28.6
Basic metal industries, fabricated metal products, machinery and equipment	1.6	2.4	1.5	17.2	9.2	86.6
Other manufacturing industries	0.7	2.3	0.1	1.8	33.5	20.8
Electricity, gas and water supply	0.7	0.8	0.0	0.0	3.5	0.0

Construction	3.8	8.5	0.1	0.4	0.0	4.8
Wholesale and retail trade, repair of personal household goods and vehicle.	4.9	6.0	0.1	0.3	1.7	82.6
Hotel and restaurants	1.8	1.4	0.1	2.3	3.4	17
Transport, storage and commutations	4.5	5.7	1.8	8.7	1.5	129.1
Financial institutions	2.0	1.7	0.1	0.9	12.4	579.0
Real estate, renting and business activities	8.9	6.2	0.1	0.6	2.5	13.6
Public administration and defense, compulsory social security.	7.5	8.6	0.0	0.0	2.8	9.2
Education	6.9	5.2	0.0	0.0	5.2	0.0
Health and social work	2.6	3.3	0.0	0.0	0.0	0.0
Other community, social and personal activity.	1.6	1.8	0.0	0.7	0.0	0.0
Private household with employed Persons.	0.6	0.4	0.0	0.0	0.0	0.0
Total	100.00	100.00	100 .00	27.40	100.00	27.8

Source: Social accounting Matrix for Saudi Arabia 2000, Chemingui (2004).

Table 4. 2 Sectoral Classification of 2000 SAM and Less Disaggregate2000 SAM of Saudi Arabia

Code in SAM 8 Sectors	Sectors in SAM 8 Sectors	Components in SAM 24 Sectors
AGRI	Agriculture	Agriculture, hunting, forestry and fishing
CRDO	Crude oil	Crude petroleum and natural gas REFI
REFI MANF	Refinery Manufacture	Petroleum refining Other mining and quarrying, basic metal industries, fabricated metal products, machinery and equipment, other manufacturing industries, wholesale, retail trade; repair of motor vehicles and personal household good, food, beverages, tobacco, textiles, wearing apparels and leather industries, wood, wood products and furniture, paper products, printing and publishing, other chemical products (except petroleum refining).
UTIL	Utility	Electricity, gas and water supply
CONST	Construction	Construction
TRDS NTRDS	Trade service Non-trade	Transport, storage, communications, financial institutions, real estate, renting, business activities, public administration, defense, compulsory social security, hotels, restaurants, other community, social, personal activity, wholesale, retail trade; repair of motor vehicles, personal household good. Education, health, social work, private households with persons employed.
SLAB	Saudi labour	
NSLAB	Non-Saudi labour	
INDTAX	Indirect tax	
GOV	Government	
S-I	Savings-Investments	
IMPTAX	Import tax	
ROW	Rest of the World	

Source: Built by author

The distinction between activities and commodities draws attention to two features of an economy. First, it allows more than one type of activity to produce a given commodity for example, agricultural activities from different regions producing both cheese and milk. In both cases, different production technologies can be highlighted. Second, activity may produce multiple commodities, for example, a dairy activity product which will feed into one national commodity. Similarly, the separation of activities and commodities allows the distinction between the sources of commodities (as domestically produced or as imports) as well as between the destinations of the commodities (as domestic sales or as exports) - Lee Harris (2002).

In this SAM there is no distinction between activities and commodities (since I borrowed the SAM, I cannot make the distinction) which result in the single entries along the main diagonal of the activity-commodity (or a one-to-one mapping between activities and commodities). This assumes that each activity produces exactly one good. This good is supplied exclusively to its own commodity market. The commodities are delivered to the domestic market either by the domestic activities (production sectors) or by the external sector through imports. Each activity is producing one type of product. Thus, the domestic supply to the domestic market is recorded on the diagonal cells.

SAM's Table (appendix 5) shows detail of all accounts as follow: The activity accounts show production by domestic industry: across the activity account rows, the amount of each commodity an industry supplies. The total amount of these commodities is SR1,084,438 million. Down the activity account column, the cost of production includes the inputs (intermediate consumption) which consists of the value of the goods and services consumed as inputs by a process of production (SR379,536 million), factors of production services in order to produce, thereby generating added value (SR692,171 million) and taxes on production paid to the government (SR12,731 million). With respect to commodity account (rows 9-18) on one hand the total income of the commodities amount is SR1,254,723 million. This amount comes from the following sources: SR379,536 million as intermediate input used by activities for production process, SR69,863 million for non-Saudi households consumption, SR261,250 million for Saudi households consumption, SR183,805 million for government consumption, SR62,730 million for investment and finally SR 297,539 million for the rest of the world consumption (exports). On the other hand the expenditure of commodities goes to the rest of the world for import costs of SR160,635 million and pay import tax to the government of SR9,650 million.

Factors

The factors of production account make up of two types of production factors capital and labour. The latter comprise of two types (Saudi labour and non-Saudi labour). Factor of production sell services to the domestic production activities and receiving compensation from these activities. The compensation of employees, which represents the payments for the use of labour in the production process, is received by the household sector through wages. The value added (SR692,171 million) is distributed among the three primary factors of production: capital (SR482,726 million), Saudi labour (SR100,483 million) and non-Saudi labour (SR108,962 million). Outlay can be made to the government and the household. Capital payment to the government represents the oil revenue accounts for SR245,883 million. However, private (household) capital represents a significant portion of total capital (49% in 2000), it accounts for SR 236,843 million transferred to Saudi household. Capital goods include: residential building construction; non-residential building construction; other construction; transport equipment; machinery and equipment; capital goods not classified elsewhere. Saudi labour transfers to Saudi households (SR100,483 million), non-Saudi labour transfers (SR108,962 million) to non-Saudi households.

Government

Government income sources and their shares are as follows: Factor (capital) income to government (SR245,883 million). This amount represent the oil revenue, it goes totally to the government account "the only owner of oil sector". The government also collect different types of tax such as production tax (activity tax) of SR12,731 million, indirect taxes (SR23,5684 million) and import tax (SR9,650 million). On the expenditure side, the government pays for commodities (SR183,805 million), and makes transfers to non-Saudi households, Saudi households and rest of the world to the amount of SR23,126 million, SR288,841 million and SR 46027 million respectively. However, the government experienced budget deficit in 2000 (SR-37,851 million).

Households

The households sector consists of all the resident households, including the Saudi and non-Saudi households. The non-Saudi household represents a significant portion of the population - it account for about 30%.

The household purchases commodities in the market, pays taxes to the government and saves. They receive incomes from the sale of their labour and capital and also transfer from the government and the rest of the world. There are two categories of households on the basis of nationality, Saudi households and non-Saudi households. Factor income (SR446,288 million) is distributed to households where Saudi households get SR337,326 million (from Saudi labour and capital income) and non-Saudi households receive SR108,962 million from non-Saudi labour. This is compensation to labour such as wages and salaries. Saudi households receive transfer of SR288,841 million from the government and SR36,728 million from the rest of the world. For non-Saudi households, they get income from non-Saudi labour (SR108,962 million) and transfers from the government as salaries and wages (SR23,126 million).

The expenditure of Saudi households include consumption goods and services (SR26,1250 million), transfers to Saudi households and the rest of the world to the value of SR104,411 million and SR79,543 million respectively, indirect tax (SR235,684 million) and savings (SR86,418 million). For non-Saudi households outlay inclusive consumption goods and services represent SR69,863 million, transfer to the rest of the world of SR57,707 million and savings of SR4,518 million.

Rest of the World - ROW (External sector)

The external sector account presents the income of the foreign sector in the corresponding row and the expenditure in the column. The income consists of imports, net transfers of companies and transfers of the government and households to the foreign sector, while the expenditure includes exports of the domestic economy, transfers to households and foreign savings. Most of these income and expenditure elements have already been explained. Furthermore, some sectoral characteristics of exports and imports have already been discussed in Chapter 2, and also are discussed together with the presentation of the CGE model Chapter 5.

Income is obtained by the ROW from sales of imports (of goods and services) to the domestic economy (SR160,635 million), transfer from the government and Saudi and non- Saudi labour to the value of SR4,6027 million, SR79,543 million and SR57,707 million respectively. ROW spends income in the domestic economy from its purchase of Saudi's exports (SR297,539 million), transfers remittances to domestic Saudi households (SR36,728 million), and shows a net capital transfer into the domestic savings-investment account (SR9,645 million).

Taxes accounts

The tax accounts are disaggregated according to the type of tax. There are three kinds of taxes received by the government: Activity (or production) tax paid by producers (SR12,731 million), indirect tax (SR235,684 million) paid by households and import tax or tariffs (SR9,650 million) paid by the non-government domestic sector.

Investments-Savings

The saving/investment account shows the consumption of household saving, government saving, foreign saving and the demand for investment commodities in the column. The savings-investment column gives the total investment expenditure in the economy. The savings-investment account accumulates savings (SR62,730 million, while spending the sum of these payments on investment demand for commodities.

4.5 Conclusion

In this chapter, the structure of SAM for the Saudi Arabia economy, for 2000 has been discussed. The structural relationships between the main institutional sectors as represented by the SAM provide an opportunity to outline some characteristics of the Saudi Arabian economy.

Chapter 5
Model and Methodology

The CGE methodology was chosen for this thesis because of the ability of this type of model to trace the effects of policy and external shocks throughout an economy. A significant feature of the methodology is the flexibility it allows in model building. It simultaneously captures the multi-market, optimising behaviours of producers and consumers, through the flexible specification of technology and preferences.

5.1 CGE Model for Saudi Arabia

The model is a static multi-sector CGE model, run for one period (2000), which closely follows the approach of Lofgren, Harris and Robinson (2002) with some changes to better fit the Saudi economy. The model explains all payments based on the Saudi SAM (2000).

5.1.1 Justifications for Adopting Lofgren et al. (2002) CGE Model

The study adopts this model because it includes a number of features designed to reflect the characteristics of developing countries. The specification follows the neoclassical-structuralist modelling tradition presented in Dervis et al. (1982). It incorporates additional features developed in recent years in research projects conducted at the International Food Policy Research Institute (IFPRI). These features, of particular importance in developing countries, include household consumption of non-marketed (or home) commodities, explicit treatment of transaction costs for commodities that enter the market sphere and a separation between production activities and commodities that permits any activity to produce multiple commodities and any commodity to be produced by multiple activities. The CGE model and the accompanying GAMS code are written to give analysts considerable flexibility. He or she can choose between alternative treatments for macroeconomic balances and for factor markets. The country database to which the model should be applied can incorporate a wide range of policy tools as well as any desired degree of disaggregation of production activities, commodities, households, and enterprises.

5.1.2 Standard Structure of CGE Model

Lofgren et al. (2002) build the standard structure of a CGE model as is explained below. The standard CGE model explains all of the payments recorded in the SAM. The model therefore follows the SAM desegregation of factors, activities, commodities, and institutions.

Activity, Production and Factors Markets

Each producer, representative of a production sector, is assumed to maximise profits subject to a production technology. Each activity uses a set of factors up to the point where the marginal revenue product of each factor is equal to its wage (also called factor price or rent).

A commodity may be produced by more than one activity. The production function has a nested structure, as illustrated in Figure 5.1. At the top level, the activity level is function of primary factors and aggregate intermediate input. The value-added and aggregate intermediate input are, in turn, functions of primary factors and disaggregated intermediate inputs, respectively. Finally, disaggregated intermediate inputs can be imported or domestic.

At the top level, the technology is specified by a Leontief function of value-added and aggregate intermediate input quantities for all sectors. Value-added is specified by a CES function of the primary factors. To determine factor demand marginal productivity of each factor equalises its price. Aggregate intermediate input demand for each activity is a Leontief function of disaggregated intermediate inputs, thus all intermediate inputs are used in fixed proportions in all activities. Commodity total demand is its marketed quantity, which is either consumed, or exported and its production is defined as the activity level times fixed yields of commodity produced by each activity. Figure 5.2 gives a schematic representation of flows of marketed commodities which are modelled as follows:

Aggregate marketed production of each commodity is composed of the marketed production of the commodity of each activity in a CES aggregation function. Marketed commodities are either exported or sold in domestic markets. A constant elasticity of transformation (CET) will be introduced to represent this hypothesis. Optimal mix between exports and domestic sales comes from the first order condition for maximisation of producer revenues given the two prices and subject to the CET function.

Whenever a commodity is only domestically sold or exported, but not both, the aggregate marketed domestic output equalises respectively the domestic sold or the exported quantity and no CET function is used for these commodities. Composite commodities that are supplied domestically are composed of those produced in the country and those imported. Imperfect substitutability between both sources is captured by a CES aggregation function of them. This is also called an Armington Function. The optimal mix between imports and domestic output is defined by the first order condition for minimisation of the cost given the two prices.

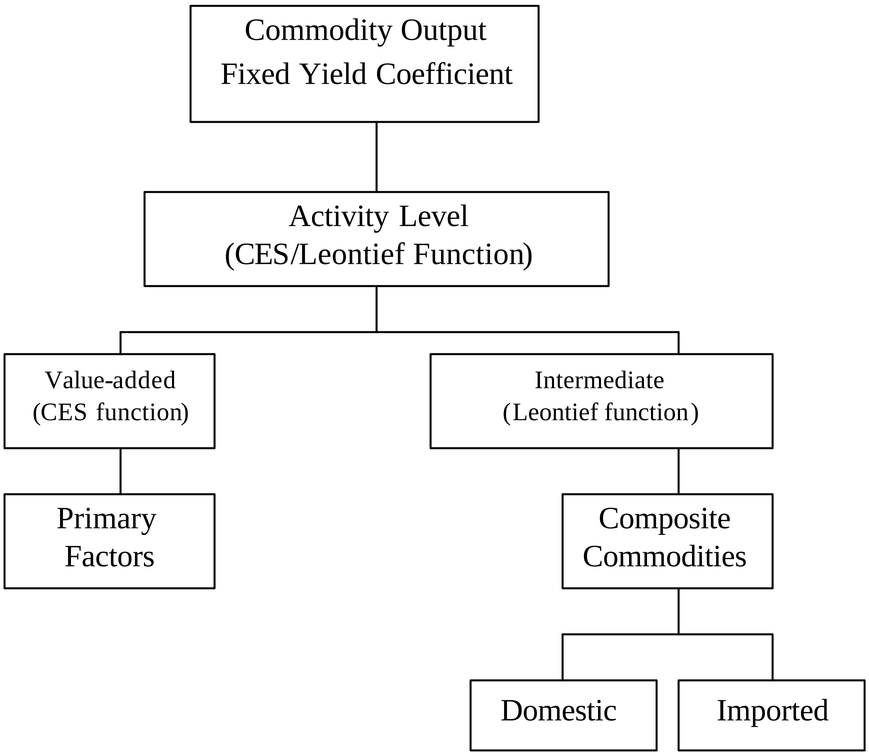
The assumptions of imperfect transformability (between exports and domestic sales of domestic output), and imperfect substitutability (between imports and domestically sold domestic output) permit the model to better reflect the empirical realities of most countries.

Institutions

Total income for each factor is defined by the sum of activity payments to factors. This income goes to domestic institutions in fixed shares. Domestic institutions are households, enterprises and the government. The households receive income from the factors of production (directly or indirectly via the enterprises) and transfers from other institutions. Transfers from the rest of the world to households are fixed in foreign currency. In fact all transfers between the rest of the world and domestic institutions and factors are fixed in foreign currency.

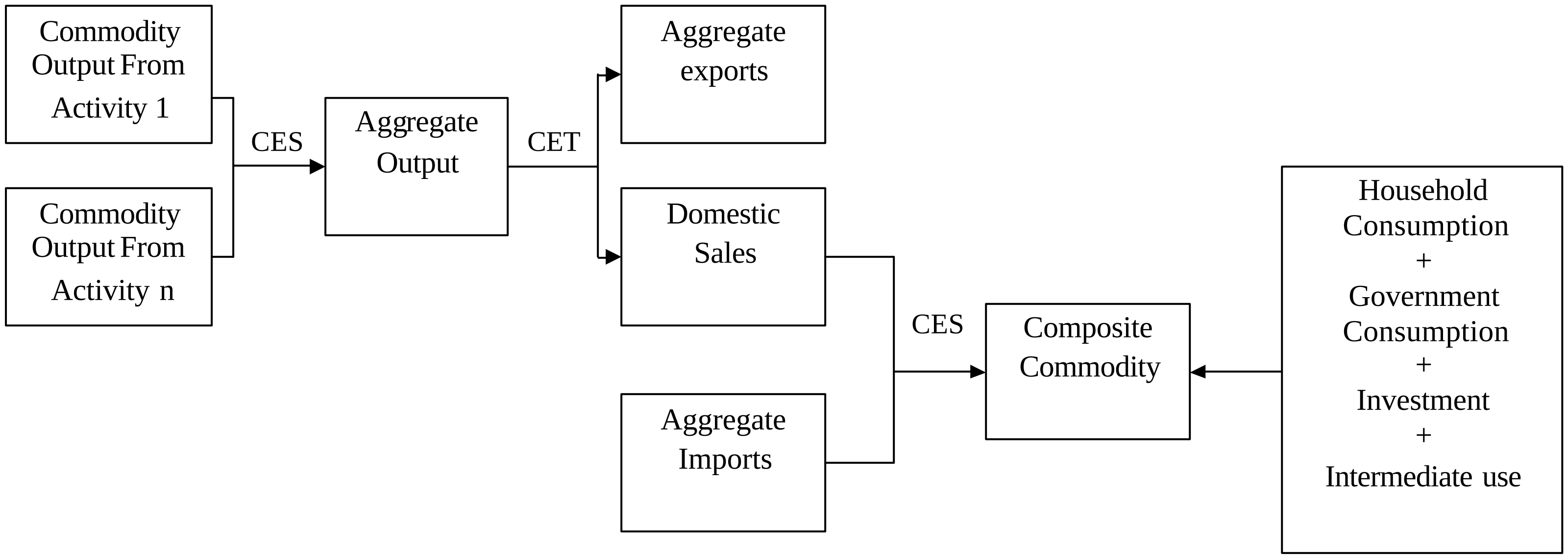
Household consumption is obtained from maximisation of their utility function. Household consumption covers marketed commodities, purchases at market prices that include commodity taxes and transaction costs, and home commodities. Enterprises may also receive transfers from other institutions. Enterprise incomes are allocated to direct taxes, savings, and transfers to other institutions. Government consumption is fixed in real (quantity) terms whereas government transfers to domestic institutions (households and enterprises) are CPI-indexed. Total government revenue is the sum of revenues from taxes, as well as transfers from other institutions and transfers from the rest of the world; and government expenditure is the sum of its consumption and transfers. The final institution is the rest of the world. As noted transfer payments between the rest of the world and domestic institutions and factors are all fixed in

5. 1 Production Technology



Source: Lofgren et al. (2002)

5. 2 Flow of Marketed Commodities



CES: Constant elasticity of substitution
CET: Constant elasticity of transformation
Source: Lofgren et al. (2002)

foreign currency.

In the Saudi CGE model producers maximise profits, while consumers maximise utility. Equilibrium is characterised by a set of prices and levels of production (i.e. market demand equals supply for all commodities), factors are fully utilised, prices are set so that equilibrium profits are zero. For oil sector profit mark-up is applied since the producer (government) act as monopolist and sets the price above unit cost. Factor incomes are divided among households (total household income is used to save and consume) while government revenue comes from indirect taxes, tariffs and oil profit. Household incomes equal household expenditures (equilibrium condition). Household goods consumption is determined by assumptions about consumer behaviour. The Armington (1969) approach allows us to treat domestically-produced and imported varieties of a good as imperfect substitutes, so that changes in relative prices lead to some (but not complete) substitution between domestic and imported goods, according to a constant elasticity of substitution (CES) function. Similarly, on the export side, according to a constant elasticity of transformation (CET) function, it may be assumed that there is imperfect transformation in production between varieties produced for the domestic market and those for foreign markets, which allows divergence between the domestic price of exportable goods and their world prices.

In this model Saudi Arabia plays the role of the dominant firm in the world oil market and the model is characterised by crude oil being a homogenous good. The world demand schedule for crude oil is downward sloping; the non-Saudi oil supply is upward sloping and the demand perceived by Saudi Arabia is determined residually.

5.1.3 Equations of the Model[18]

The complete set of equations for the Saudi static model is explained in detail as follows:

Production Function

Production is carried out by activities that are assumed to maximise profits subject to their technology, taking prices (for their outputs, intermediate inputs and factors) as given. In other words it acts in a perfectly competitive setting. The CGE model includes the first order conditions for profit-maximisation by producers. The Cobb-Douglas form of the production function is used to determine output in all sectors (Equation 1). Production technology is characterised by constant return to scale. Primary factors used in the production process are labour and capital.

5.1.4 Justification for Adopting Cobb-Douglas Function

Cobb-Douglas is the most popular neoclassical production function that has been extensively used. It has long been popular among economists because it is easy to work with. The Cobb-Douglas is a special case in a more general class of production functions with Constant Elasticity of Substitution (CES). Economists have also been somewhat well disposed toward Cobb-Douglas because it gives simple closed-form solutions to many economic problems. The function is based on restrictive assumptions of perfect competition in the factor and product markets.

Bhanumurthy (2002) argues the merits and demerits of the Cobb-Douglas function and concludes that this function is preferable because of the advantages it posseses. These advantages are due to the fact that it can handle multiple inputs in its generalised form.

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[18] Sets, variables and parameters are defined in appendix 3.

Even in the face of imperfections in the market it does not introduce distortions of its own. Unconstrained CD-function further increases its potentialities to handle different scales of production. Various econometric estimation problems, such as serial correlation, hetroscidasticity and multicolinearity can be handled adequately and easily. It is argued that most of its criticism is focused on its inflexibility and admits that except for one obvious assumption all other assumptions can be relaxed. It is further argued that it facilitates computations and has the properties of explicit representability, uniformity, parsimony and flexibility. Even the problem of simultaneity can be accounted for through the use of stochastic CD-production function. The paper argues that the technology can also be well represented by it.

A major drawback of the Leontief input-output analysis, as pointed out by Liew (1988b) is an inability to trace the effect of outputs associated with a cost or price change because the use of the fixed technological coefficients of production fails to permit any input substitution. Efforts to include more flexible production coefficients, as in the Cobb-Douglas or CES function, into a Leontief production function have been made. Chenery and Raduchel (1971) introduced a linear programming (LP) model by allowing CES to substitution between primary factor inputs, i.e. labour and capital. Dervis, De Melon, and Robinson (1982) on the other hand introduced a computable general equilibrium model (CGE) in which a CES technology is used to allow the substitution among labour, capital, and materials inputs.

Each activity produces a final goods using:

(i) all the primary factors under a Cobb-Douglas production function

$$QA_a = ad_a \prod_{f \in F} QF_{fa}^{\alpha_{fa}}; \quad a \in A \tag{1}$$

where constant return to scale requires $\sum_f a = 1;\ a \in A$, since the elasticity of substitution between factors is constant.

QA_a is the activity level (domestically produced output by activity a), ad_a the production function efficiency parameter, $QF_{fa}^{a_{fa}}$ the quantity demanded of factor f by activity a, and a_{fa} is Cobb-Douglas share parameter of factor f for activity a.

(ii) all the final goods as intermediate according to a fixed input-output coefficients as follows:

Intermediate Input

The CGE model assumes fixed coefficients for intermediate demand. This is the assumption of the Leontief input output technology. Since the ratios of intermediate inputs to outputs and the shares among intermediate inputs in each sector remain fixed, equation 2 represents the demand for intermediate inputs. For each activity, the demand for disaggregate intermediate input is determined via a standard Leontief formulation as the level of aggregate intermediate input used times a fixed intermediate input coefficient.

$$QINT_{ca} = ir_{ca}\ QA_a\ ;\quad a \in A,\quad c \in C \tag{2}$$

where input requirement coefficient ir_{ca} is in terms of the final good QQ which should satisfy $\sum_{c \in C \cup F} ir_{ca} = 1\ ;\ a \in A,$

Value Added

Producers hire factors of production (e.g. labour and capital) to maximise their profit. The first order condition for profit maximisation suggests that factors of production are hired until their per unit rental cost is equal the value of their marginal products in each sector. Value added unit formulated as the sum of the factor price distortion FPD_{fa} multiplied by factor price PF_f multiplied by factor demand QF_{fa}

$$PVA_a . QA_a = \sum_{f \in F} FPD_{fa} . PF_f . QF_{fa} \tag{3}$$

Factor price distortion, measures the deviation of the marginal revenue product of a factor in a particular sector from the average return for that factor across the economy. It can be fixed exogenously or varied endogenously depending upon the factor market closure adopted in the model. In other word it is a convenient way to allow for a flexible modelling.

Output of Commodity From All Activities

Output of commodity c is defined as the sum of the activity level a times fixed yields of commodity c produced by activity a,

$$QX_c = \sum_{a \in A} q_{ac} . QA_a ; \quad c \in C \tag{4}$$

the shares should satisfy $\sum_{a \in A} q_{ac} = 1; \quad c \in C$

Activity Price

The return from selling the output of the activity (the gross revenue per activity unit), is defined as the sum over all commodities of the fixed yields per activity unit q_{ac} multiplied by producer prices PX_c in activity a , allowing activities to produce multiple commodities.

$$PA_a = \sum_{c \in C} q_{ac} . PX_{c;} \quad a \in A \tag{5}$$

If an activity produced more than one commodity, q_{ac} equals the share of each commodity in total output of the activity and the shares should satisfy $\sum_{c=C} q_{ac} = 1$. If an activity produces only one commodity as in this model, there is a one-to one relationship between A and C ($a = c$), q_{ac} equals one.

The revenue, cost and profit resulting from each activity can be formulated as follows:

Revenue of Non-Oil Activity

Revenue of activity a = total cost of activity a

$$PA_a \,.QA_a = TCST_a \;;\; a \in A \tag{6A}$$

Revenue of Oil Activity

Revenue of oil is different from activity of non-oil revenue since Saudi Arabia applies the profit mark-up as it is explained in equation 24. So,

Revenue of oil activity a = total cost of activity a ($TCST_a$) + profit of activity a ($PROF_a$).

$$PA_a \,.QA_a = TCST_a + PROF_a;\; a \in A \tag{6B}$$

Total Cost

$$TCST_a = FCST_a + MCST_a + ACTAX_a \tag{7}$$

Total cost in activity a = factor cost + material cost + activity tax

Factor Cost

$$FCSTa = PVA_a .QA_a \;;\; a \in A \tag{8}$$

Factor cost in activity a = value added in activity a

Material (Intermediate) Cost

$$MCST_a = \sum_{c \in C} PQ_c . QINT_{c,a} \, ; a \in A \tag{9}$$

Material cost in activity a = sum of the value of intermediate inputs of commodity c in activity a multiplied by composite price of commodity c .

Composite Supply (Armington) Function

Composite commodities that are supplied domestically are composed of those produced in the country and those imported. Imperfect substitutable between both sources is captured by a CES (Constant Elasticity of Substitution) aggregation function of them. This is also called an Armington[19] function as the following equation:

$$QQ_c = aq_c . \left((1-dq_c).QD_c^{-rq_c} + dq_c.QM_c^{-rq_c}\right)^{-1/rq_c} ; \quad c \in CM \tag{10}$$

Import -Domestic- Ratio

The import-domestic-ratio defines the optimal mix between imports and domestic output. The ratio is derived from the first order condition for minimisation of the cost given for the two prices. It suggests that an increase in the domestic-import price ratio generates an increase in the import-domestic demand ratio. In this case the demand shifts away from the source that becomes more expensive, (Lofgren, Harris, and Robinsons, 2002).

$$\frac{QM_c}{QD_c} = \left(\frac{dq_c}{1-dq_c} . \frac{PD_c}{PM_c}\right)^{sq_c} , \qquad sq_c = \frac{1}{1+rq_c} \rangle 0; \quad c \in CM \tag{11}$$

where elasticity of substitution between commodities from these two sources is given by

$s\,q_c = 1/1 + r\,q_c$, $s\,q_c > 0$, $r\,q_c > -1$, rq_c is an exponent used in (CES constant

[19] Armington (1969) is a reference for most studies of trade agreements.

elasticity of substitution) aggregation function.

Composite Absorption) Price

Composite price is expressed as the total price of the commodity produced and sold domestically and the price of the imported commodity plus the sales tax. Thus the sales tax is imposed on both domestically produced goods as well as imports (which are already tariff-ridden). Composite price is represented by the following equation:

$$PQ_c . QQ_c = (PD_c . QD_c + PM_c . QM_c)(1 + tq_c); \quad c \in CM \tag{12}$$

Import Price

The price of imported commodities in domestic currency units (PM_c) depends on the world price of the commodity (PWM_c) in foreign currency , tariff rates (tm_c) and the exchange rate (EXR) local currency per foreign currency. We assume that Saudi Arabia is a small country, which implies that Saudi Arabia is a price taker and therefore, the world price of imports is an exogenous. The price of imports measured in local currency is therefore given by:

$$PM_c = (1 + tm_c) PWM_c . EXR; \quad c \in CM \tag{13}$$

Equation (10) can be reduced to equation (14) when there is no import (QM_c=0) as follows:

$$QQ_c = QD_c \quad c \in CNM \tag{14}$$

Once there are no import commodities, PM_c and QM_c are fixed at zero for commodities that are not imported and equation (12) is reduced to:

$$PQ_c . QQ_c = PD_c . QD_c (1 + tq_c); \quad c \in CNM \tag{15}$$

Output Supply (Sales Quantity)

It shows the output supply QX_c as CET function of the commodity supplied to export market QE_c as well as supplied to the domestic market QD_c. This implication of imperfect transformability between domestically sold and exported goods allows each sector to produce differentiated goods for the export and domestic markets. Domestic producers then maximise profits subject to this equation. The output supply equation is formulated as follows:

$$QX_c = ax_c . \left((1 - d\,x_c) . QD_c^{r\,x_c} + d\,x_c . QE_c^{r\,x_c} \right)^{1/r\,x_c} ; \quad c \in CE \tag{16}$$

Domestic- Export Ratio

The export- domestic supply ratio is a function of the export- domestic price ratio, which is derived from the first order condition of profit maximisation which defines the optimal mix between exports and domestic output. It assures that an increase in the export- domestic price ratio generates an increase in the export- domestic supply ratio. In other words, the supply will shift toward the destination that offers the higher return (Lofgren, Harris, and Robinsons 2002). Clearly, this gives rise to the export price PE_c diverging from the domestic price PD_c.

$$\frac{QE_c}{QD_c} = \left(\frac{1 - dx_c}{dx_c} . \frac{PE_c}{PD_c} \right)^{sx_c} , \qquad c \in CE \, . \tag{17}$$

The elasticity of transformation is given by $sx_c = \dfrac{I}{rx_c - 1}$, rx_c is an exponent used in CET (constant elasticity of transformation) aggregation function.

Producer (Output for Exportable & Non-Exportable) Price

The marketed output value at producer prices for each commodity produced domestically is expressed as the sum of domestic sales and exports each valued at the prices received by the suppliers. The marketed value of output is therefore represented by the following equation:

$$PX_c . QX_c = PD_c . QD_c + PE_c . QE_c ; \quad c \in CE \tag{18}$$

Export Price

When domestic producers sell their output in export markets they receive an export price PE_c in local currency unit which equals world export price multiplied by exchange rate minus subsidy:

$$PE_c = (1 - te_c) PWE_c EXR \tag{19}$$

Or

In case a commodity which is not exported:

$$QX_c = QD_c \tag{20}$$

For a commodity which is not exported but only sold on the domestic market, PE_c and QE_c are fixed at zero in the model and the above equation becomes as follows:

$$PX_c . QX_c = PD_c . QD_c ; \quad c \in CNE \tag{21}$$

Average Cost

In this model as it is mentioned above each activity produces only one commodity, there is a one-to one relationship between A and C, accordingly, the average cost of commodity c $AVCST_c$ = average cost of activity a $AVCST_a$

$$AVCST_c = AVCST_{a,} \quad \text{where} \quad AVCST_a = \frac{TCST_a}{QA_a}; \quad a \in A \tag{22}$$

Profit of Activity and Commodity

One-to one relationship between A and C can be applied to profit equivalence of activity a and commodity c,

$$PROF_c = PROF_{a,} \tag{23}$$

Since Saudi Arabia is considered a monopoly producer in the oil market, it applies the profit mark-up in its oil profit $(PX_a - AVCST_a)$ using the elasticity of demand to set price above unit cost. This applied to the oil activity/commodity only.

$$PROF_c = (PX_c - AVCST_c)QXc; \quad c \in C \tag{24}$$

For other activities, profit is set to zero since $PX_a = AVCST_a$

Oil Output

For oil activity related commodities, oil output equals quantity of oil sold domestically and exported:

$$QX_c = QD_c + (QE_c + QEODUM); c \in CO \tag{25}$$

$QEODUM$ this dummy variable is used in simulation, it is zero if there is no shock.

The value of sold oil equal the total value of oil sold domestically and exported oil.

$$PX_c QX_c = PD_c QD_c + PE_c (QE_c + QEODUM); \; c \in CO \tag{26}$$

Domestic Oil

In case the oil commodity is sold domestically and not exported, then the composite good purchased by domestic dema nder equals domestic quantity purchased.

$$QQ_c = QD_c; \; c \in CO \tag{27}$$

The price paid by domestic users is subsidised, it equals producer price PX_c minus subsidy as in the following equation:

$$PD_c = PX_c(1-osub); c \in CO \tag{28}$$

Perceived Demand for Oil by ROW (Oil Exports)

Given the significant market share of Saudi oil in the world oil market, oil export QE_c can be determined on the basis of the country's price setting power in the world market. To formulate QE_c, we assume that the quantity of exported oil is determined by the following equation:

$$\left(QE_c + QEODUM\right) = ROWOD_c - ROWOS_c; c \in CO \tag{29}$$

As a result, Saudi Arabia can operate on this residual demand as a monopolist.

Total Demand for Oil by Rest of the World

With regard to the demand for crude oil, for the sake of simplicity, it is assumed that the world oil import demand function, $ROWOD$, and world oil supply function, $ROWOS$, are constantly elastic[20]. Hence,

$$ROWOD = \overline{ROWOD}\left[(1+to)PWE_c\right]^{-e_{rowod}}; \quad c \in CO \tag{30}$$

and

$$ROWOS = \overline{ROWOS} \cdot PWE_c^{e_{rowso}}; \quad c \in CO \tag{31}$$

Perceived Price Elasticity of Oil Export Demand

The price elasticity of demand perceived by the dominant firm (Saudi Arabia) is endogenous, depending on the responses to shock of world demand and the rest of the world supply. Hence, the price set by a dominant firm can fluctuate greatly. (De Santis 2003).

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[20] An econometric study by Hogen (1992) rejects linear demand models for crude oil in the OECD countries in favor of constant elasticity formulations.

From equations (29) - (31) we can formulate the following equation[21]:

$$(QE_c + QEODUM) \cdot e = ROWOD \cdot e_{rowod} + ROWOS \cdot e_{rowos};\ c \in CO \qquad (32)$$

- **Monopolist and Price Elasticity of Demand**

As a price setter the monopolist can choose the price and leave the consumers (via demand) to determine the output that can be sold at that price. Alternatively the monopolist can choose the output and leave consumers (via demand) to determine the price at which that can be sold. The monopolist will operate max profit at point on the demand curve where the elasticity of demand is greater than or equal to unity.

Domestic Oil Export Price

The domestic oil export price is a function of the average cost and the elasticity of the oil price.

$$PE_c = \frac{AVCST_c}{(1-1/e)};\ c \in CO \qquad (33)$$

World Oil Price

World oil price is equal to the domestic oil price times the exchange rate.

$$PWE_c = PE_c \cdot EXR;\ c \in CO \qquad (34)$$

Transfer of income from factor to household:

The significant part of the household income is the transfer from factors which are distributed among the households in fixed share, determined by $shry_{hf}$ (calibrated from the SAM, Appendix 1). Income from factors accrued to household are as the following equation:

[21] See appendix 2 for derivation equation 32 and 33

$$YF_{h\,f} = shry_{h\,f}\left(\sum_{a\in A} FDP_{lab,a}\, PF_{lab} QF_{lab,a} + \sum_{a\in ANO} FDP_{cap,a}\, PF_{cap} QF_{cap,a}\right) \tag{35}$$

shares should satisfy: $\sum_{h\in H} shry_{hf} = 1; \qquad f \in F$

Transfer of Income from Labour to Household

Is the sum transfer of income from labour factor f ($f \in LAB$) to household h.

$$YLABH_h = \sum_{f\in LAB} YF_{h\,LAB} \tag{36}$$

Transfer of Income from Capital to Government

This capital transfer is original oil activity

$$YF_{g,cap} = \sum_{a\in AO}\left(FDP_{cap,a} PF_{cap} QF_{cap,a} + PROF_a\right) \tag{37}$$

Income of Household:

The total household income YH_h is defined as the sum of factor incomes YF_{hf}, transfered from the government TR_{hg} and the rest of the world TR_{hr} as follows:

$$YH_h = \sum_{f\in F} YF_{h\,f} + TR_{h\,g} CPI + EXR \cdot TR_{h\,r} \tag{38}$$

Direct tax from Household

This is a fixed proportion of the residual household income after pensions and other transfers are subtracted:

$$DTAX_h = ty_h\left(YH_h - tp_h YLABH_h - OTR_{g,h}\right) \tag{39}$$

Disposable Income for Household

Disposable income is the residual household income after subtracting direct taxes, pensions and other transfers to the government.

$$DIH_h = YH_h - DTAX_h - tp_h YLABH_h - OTR_{g,h} \qquad (40)$$

or

Disposable income equals the total of household expenditure, household savings and transfers to the rest of the world.

$$DIH_h = EH_h + SH_h + TR_{r,h} \qquad (41)$$

Transfer from Household to Rest of the World

Transfer from household to rest of the world is calculated as a fixed proportion of household disposable income.

$$TR_{r,h} = mpt_h DIH_h \qquad (42)$$

Household Saving

Household saving is a fixed proportion of the residual of disposable household income after transfer to rest of the world.

$$SH_h = MPS_h \left(DIH_h - TR_{r,h} \right) \qquad (43A)$$

Marginal Propensity to Save for Household

This can be formulated as an initial marginal propensity to save multiplied by adjusted marginal propensity. This adjustment variable is used for simulations in which saving is scaled up or down. When MPS is flexible, in this case *MPSADJ* moves between $0 < MPSADJ < 1$ and the dummy variable $mpsdum_h$ equals to one. The opposite is when $mpsdum_h$ equals zero then $MPS_h = mp\sin_h$.

$$MPS_h = \mathrm{mpsin}_h \left(1 + MPSADJ \cdot \mathrm{mpsdum}_h \right) \qquad (43B)$$

Household Consumption

Household consumption is share of consumption times household expenditure relative to price of composite price.

$$QH_{c,h} = b_{c,h} EH_h / PQ_c \tag{44}$$

Household Utility:

Households use their income to demand commodities use for consumption and savings. Therefore, the total value of their consumption expenditure (QH_{ch}) is simply what remains from their disposable income after savings. For each household h the Cobb-Douglas utility function can be written as follows:

$$UTILH_h = \prod_{c \in C} \left(QH_{c,h} / b_{c,h} \right)^{b_{c,h}} \tag{45}$$

the shares should satisfy:

$$\sum_{c \in C} b_{ch} = 1; \qquad h \in H .$$

Household Consumer Price Index

Household consumer price index is a function of composite price,

$$CPIH_h = \prod_{c \in C} PQ^{b_{c,h}} \tag{46}$$

Price Normalisation.

We need to normalise the price system so that overall prices are kept constant at a fixed value. In order to normalise prices at some fixed value the common approach is to establish a price index weighted average price of consumer price of household and set the value of this index to unity. Consumer price index is formulated as follows:

$$CPI = \sum_{h \in H} m_h \cdot CPIH_h \tag{47A}$$

and the weight of household utility in the CPI is,

$$m_h = \frac{UTILH_h}{\sum_{h \in H} UTILH_h} \qquad (47B)$$

where the share should satisfy: $\sum_{h \in H} m_h = 1$ and the CPI is fixed a priori, e.g. $CPI = 1$

Investment Demand:

Quantity of investment can be formulated as initial investment in base run multiplied by investment adjusted ($IADJ$), an adjustment variable is used for simulations in which investment is scaled up or down. There are two cases: Investment is flexible and saving is fixed. In this case the adjustment ($IADJ$) changes up or down 0< $IADJ$ <1 to clear the market. The opposite is when we treat investment as exogenous across h and MPS_h adjust to clear the market, the adjustment ($IADJ$) equals to one.

In this study I use both cases, for Saudi households I assume saving is flexible and investment fixed and vice-versa for non-Saudi households, since non-Saudi households do not save their income but transfer it to their home countries. Investment-driven saving assumption is commonly used in literature (Adelman and Robenson, 1988; Farmer and Wendner, 2001; Al-Thomairi, 2006). The following equation formulates the investment demand:

$$QINV_c = \mathrm{inv}_c \, IADJ \qquad (48)$$

Government Budget Surplus:

The government budget surplus equals revenue less expenditure. Government revenue sources include activity tax, indirect taxes, tariff revenue on imported goods and revenue from oil profit (the government owns the capital and oil in the oil sector).

The government expenditure including government consumption (good and services) which are exogenously fixed quantities for each commodity, oil price subsidy, transfer to the household. Government transfers to the households are CPI - indexed, that is, they can simply be fixed in nominal terms. The government budget surplus formulated as follows:

$$\begin{aligned} GBS = {} & YF_{g,cap} + EXR \cdot TR_{g,r} - TR_{r,g} + \sum_{a\in A} ACTAX_a \\ & + \sum_h \left(DTAX_h + tp_h YLAB_h + OTR_{gh} - CPI \cdot TR_{h,g} \right) \\ & + \sum_{c\in C} tq_c PD_c QD_c + \sum_{c\in CM} tq_c PM_c QM_c + \sum_{c\in CM} tm_c EXR \cdot PWM_c QM_c \\ & - \sum_{c\in CE} te_c EXR \cdot PWE_c - \sum_{c\in CO} subo \cdot PD_c QD_c - \sum_{c\in C} PQ_c . QG_c \end{aligned} \tag{49}$$

Factor Market Equilibrium

Aggregate demand for labour equals labour supply. In case there is no excess supply (unemployment) this term is equal to zero, $QFU_f = 0$. This is done in order to capture the labour market properties[22].

Factor market equilibrium formulated as follows:

$$\sum_{a\in A} QF_{fa} - QFU_f = QFS_f \tag{50}$$

Good Market Equilibrium

In the goods market, the main mechanism works through the relative price system. Equation 51 shows the equilibrium condition in the goods market, it requires demand equal supply at privilege price. Supply side is the composite good QQ_c for commodity c, the demand side is the sum of intermediate input demand $QINT_{ca}$, household

[22] More detail is discussed in closure rule at the end of this chapter.

consumption demand QH_{ch}, government consumption demand QG_c and investment demand $QINV_c$.

$$QQ_c = \sum_{a \in A} QINT_{ca} + \sum_{h \in H} QH_{ch} + QG_c + QINV_c \tag{51}$$

Balance of Payment

The current-account balance, which is expressed in foreign currency, imposes equality between the country's spending and its earning of foreign exchange. We set EXR exogenously to the desired value (EXR=1) and allow BOP to be determined by the excess supply or demand. Balance of payment equation as follows:

$$\begin{aligned} BOP = & \left(\sum_{c \in CM} PWM_c QM_c + \sum_{i \in I} TR_{ri} / EXR \right) \\ & - \left(\sum_{c \in CE} PWM_c QE_c + \sum_{c \in CO} PWE_c (QE_c + QEODUM) + \sum_{i \in I} TR_{ir} \right) \end{aligned} \tag{52}$$

Walras: Introducing a dummy endogenous variable $WALR$ is used to provide a consistency check the equality between values of savings and investment where $WALR$ =0 as the following equation:

$$WALR = \sum_{h \in H} SH_h + GBS + EXR \cdot BOP - \sum_{c \in C} PQ_c QINV_c \tag{53}$$

5.1.5. Household Welfare Measures

Policy analysts often refer to welfare indicators to evaluate the impact of a policy change. The most commonly used welfare indicators are the compensating variation and the equivalent variation. They measure a change in income that is necessary to offset a change in price so that a consumer's utility remains at a given level. Leung and Robert (2007) define compensating variation and equivalent variation as follows:

Compensating Variation (CV): Is the maximum amount of income that could be taken from someone who gains from a particular change while still leaving them no worse off than before the change.

Equivalent Variation (EV): Is the minimum amount that someone who gains from a particular change would be willing to accept to forego the change.

The key distinction between these two measurements is that the equivalent variation is calculated using the new, lower utility level, whereas the compensating variation is based on the original utility level. However, CV and EV can be computed algebraically using household expenditure before and after shock as the following equations[23].

$$EV = \left(\frac{CPIH_h^0}{CPIH_h^1}\right) EH_h^1 - EH_h^0 \qquad (54)$$

$$CV = EH_h^1 - \left(\frac{CPIH_h^0}{CPIH_h^1}\right) EH_h^0 \qquad (55)$$

Subscript 0 and 1 denote to the two situations before and after price change.

5.1.6 Closure Rule

The equilibrium results of the CGE model and their implications with respect to policy analysis depend upon how the model is closed. Closure rules arise from the problem of deciding which prices and quantities must be made exogenous to derive a model where the number of equations is equal to the number of endogenous variables.

In mathematical terms the model should consist of an equal number of independent equations and endogenous variables. In a sense closure rules reflects the

[23] see appendix 2 for derivation of equation 54 and 55.

choice of the model builder of which variables are exogenous and which variables are endogenous.

There is no financial sector in this model. Unlike developed countries or new industrialised countries (India or China), Saudi Arabia does not have an advanced financial market which provides all information that are needed to be included in CGE model.

One of commodities or factor of production ought to be used as a numeraire whose price is normalised to unity. Instead of doing so, I have chosen to implement the price normalisation rule in terms of the consumer price index (CPI) based on Cobb-Douglas.

The government consumption is fixed in real terms, and its transfers to households are CPI–indexed, all tax rates are fixed. All transfer to or from the rest of the world are exogenous. In the labour market, there are three factors of production, Saudi labour, non-Saudi labour and capital.

The following assumptions are implemented in terms of the closure rule:

Saudi labour: labour mobile across sectors, no wage distortion is allowed, labour supply is kept fixed to capture the short-run nature of the experiment, there is no unemployment, wage is allowed to adjust to clear the market.

Non-Saudi labour: is assumed to be immobile across sectors and fully employed. wage and labour demand are kept fixed while wage distortion is flexible to clear the market.

Capital market: capital input is treated as activity specific and hence immobile. The capital used in production is kept fixed and return to capital is determined for each activity to clear the market where capital supply is kept fixed to capture the short-run nature of the experiment.

Investment-Savings closure: Neoclassical views suggest that savings is exogenous, and that investment adjusts passively to maintain the savings-investment balance. By contrast, a more Keynesian view reverses the causality found in neoclassical theory by arguing that investment is exogenous and that savings adjusts to clear the market. (Thurlow 2004). Recent work on this issue concluded that the saving-investment relationship in Saudi Arabia has been one characterised by exogenous investment (Al-Thumairi 2006). In the absence any financial sector, the overall equilibrium requires the value of aggregate net investment (gross investment adjusted for capital consumption) to match national saving. This study assumes that savings are flexible for Saudi households and investment is fixed, and vice versa for non-Saudi households, since the latter transfer their income to their countries as a remittance and hence, they do not save.

Exchange rate: To ensure the balance of payments equilibrium, exchange rate is treated as exogenous (fixed) and the balance of payments is allowed to adjust endogenously.

5.1.7 Calibration

The design of a CGE model requires several steps. First, the structure of the general model is determined. Then, a particular functional form has to be chosen for the production and demand functions. Usually Cobb-Douglas, Linear Expenditure System (LES) or Constant Elasticity of Substitution (CES) specifications are selected for this purpose. Finally, the parameter values for the functional forms must be derived. Ideally all the parameters in the CGE model may be econometrically estimated, using simultaneous equation estimation methods that take into account the overall model structure. However, given the required sophistication of techniques and the lack of data, this procedure is not considered feasible. Therefore, the most commonly used procedure to determine the parameter values is calibration. The calibration procedure ensures that the parameters of the model are specified in such a way that the model will reproduce the initial data set as an equilibrium solution.

Once the parameters are calibrated the model is complete and different policy changes can be simulated. The parameter values are crucial in determining the results of policy simulations. A schematic presentation outlining the calibration procedure and the CGE model use is given in Figure 5.3 (Shoven and Whalley, 1992).

For CGE models there are essentially two kinds of parameters that need to be estimated: Share parameters such as intermediate input costs, consumer expenditure shares, average savings rates, import and export shares, government expenditure shares, and average tax rates. These share parameters can be estimated from a recent social accounting matrix (SAM) under the assumption that the base year represented by the SAM is an equilibrium solution of the CGE model.

The following parameters were calibrated using the data in the SAM: the elasticity (a) in production, the shift coefficient in production function (ad), the marginal propensity to save (MPS) for each of the household and household consumption share (b). The imports and exports are represented by CES and CET functions.

The elasticity parameters were used along with the information contained in the SAM to calibrate the shift and share parameters. For example, the shift parameter

(ax),and (aq) and the share parameter (d_{ax}), (d_{aq}) of composite goods are calibrated by solving (ax), (aq), (d_{ax}), (d_{aq}) and (r_q), (r_x). A list of parameters and equations of calibrating parameters are presented in Appendix 1.

Elasticity parameters describing the curvature of various structural functions (e.g. production functions, utility functions, import demand functions, export supply functions). These cannot be estimated from a single SAM, but require additional data. The benchmark data (SAM) gives us the number of these parameters but not all of them. Since time-series or cross-sectional data to estimate parameters econometrically are not readily available and complicated to estimate, parameter values have to be

Table 5.1 Elasticity Values of CES and CET Functions.

	s_q	s_x
AGRI	2.20	1.50
CRDO	2.80	1.50
REFI	2.80	1.50
MANF	1.90	1.50
UTIL	1.90	1.50
CONS	1.90	1.50
TRDS	1.90	1.50
NTRDS	1.90	1.50

Source: De Santis (2003).

s_q elasticity of constant elasticity of substitution function.

s_x elasticity of constant elasticity of transformation function.

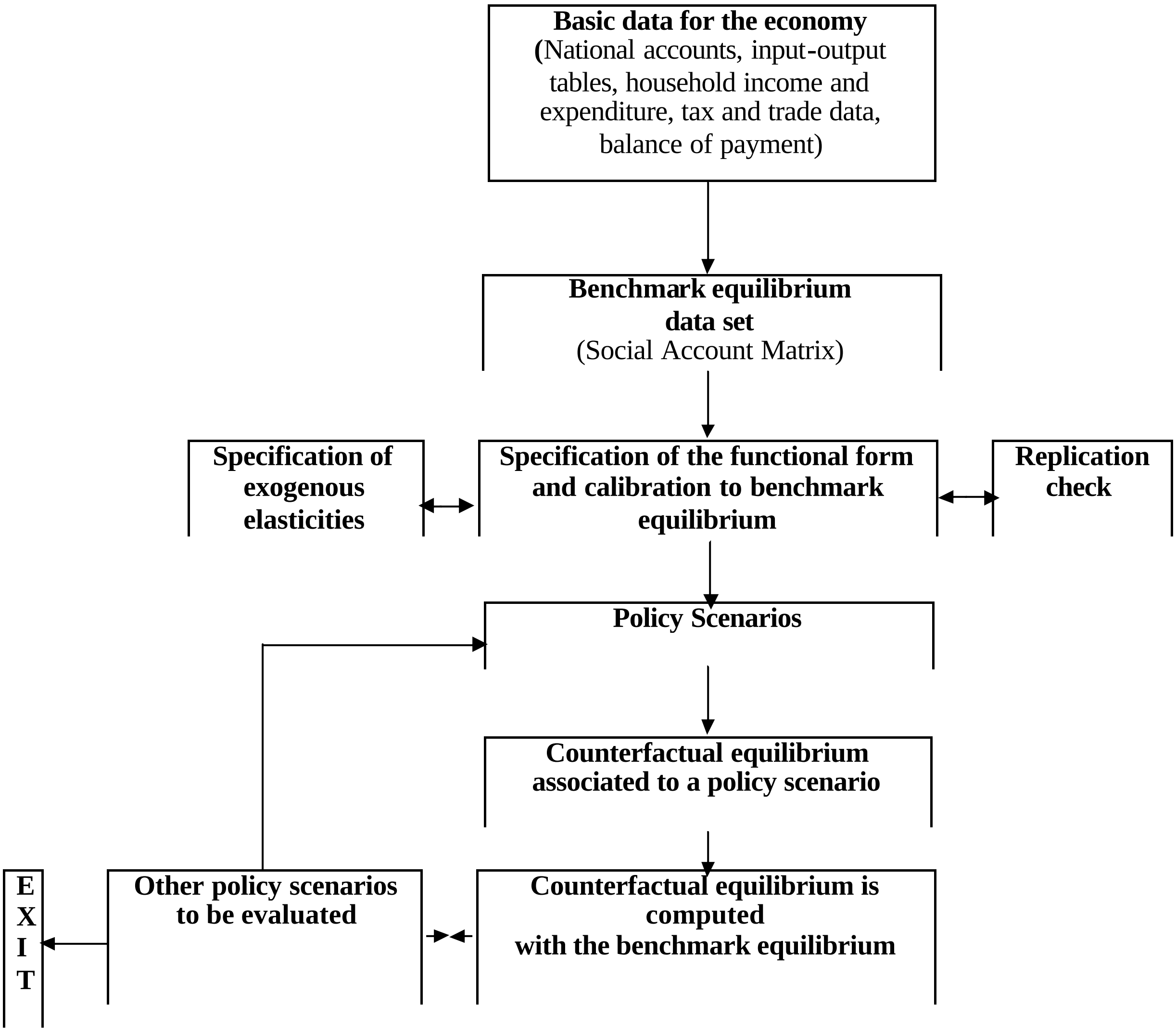
borrowed from previous studies on Saudi Arabia or similar applications to other countries. We borrowed those elasticity values including Constant Elasticity of Substitution (CES) or Constant Elasticity of Transformation (CET) from De Santis (2003).

We prefer these values because De Santis (2003) in his study about crude oil price fluctuations and Saudi Arabia's behaviour used these parameters. He points out that the Armington elasticity values for agriculture and manufacturing are high so as to capture the fact that Saudi Arabia is relatively small. The CET is set equal to 1.5 for all tradable differentiated goods. This elasticity is small to capture the fact that little of the non-oil output is export-oriented. The world price elasticity of demand and the RoW supply elasticity for crude oil have been estimated by Alhajji and Huettner (2000) for the dominant firm model, which is consistent with Saudi Arabia's behaviour: 0.49 and 0.212. Table 5.1 lists the parameter values used in the calibration of the CGE model.

5.2 Conclusion

The real CGE model developed in this chapter provides a general framework for modelling the Saudi model and follows the approach of Lofgren, Harris and Robinson (2002). It incorporates the behaviour of government, the household sector, and the rest of the world sector. The tax system is represented in a detailed way. The model is calibrated on the SAM for 2000.

5. 3 Commodities Flow Chart outlining Calibration Procedures for the Saudi SAM



Source: Shoven and Whalley, 1992

Chapter 6

Simulation Results

6.1 First Experiment

6.1.1 First Simulation (SIM-1)

i. Macroeconomic Effects of Increase Oil Demand by 5%

Table 6.1 and Figure 6.1 summarise the impact of the experiment on selected macroeconomic variables. Increasing oil demand by 5% would increase the oil export price by 7.21%. Since oil exports dominate total exports (67.52%), the latter increase by 5.50%. Total imports register an expansion account for 2.54% as a result of the oil demand shock. The increase in oil demand significantly improve oil profit (PROFC) by 37.50% which reflected in slight increase in GDP by 0.73% at factor cost and remarkable increase (5.52%) at market price. Government revenue (GR) witnesses progress of 9.27%, which in turn promotes investment by 51.65%. However, government consumption and private consumption falls (-0.20% and -1.46% respectively) due to the increase in composite price (PQ)[24].

ii. Effect on Prices and Volumes of Commodities

The price and volume effects of SIM-1 are presented in Table 6.2. Increase oil demand results in a negligible reduction in the overall domestic price of imports (PM). However, since the decline in PM is insufficient to lower the overall domestic price for composite price (PQ) by 13.26%.

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[24] For more detail see equation (44) and (49), chapter (5).

Table 6.1 Macroeconomic Effects of Increase Oil Demand by 5% (SIM -1)

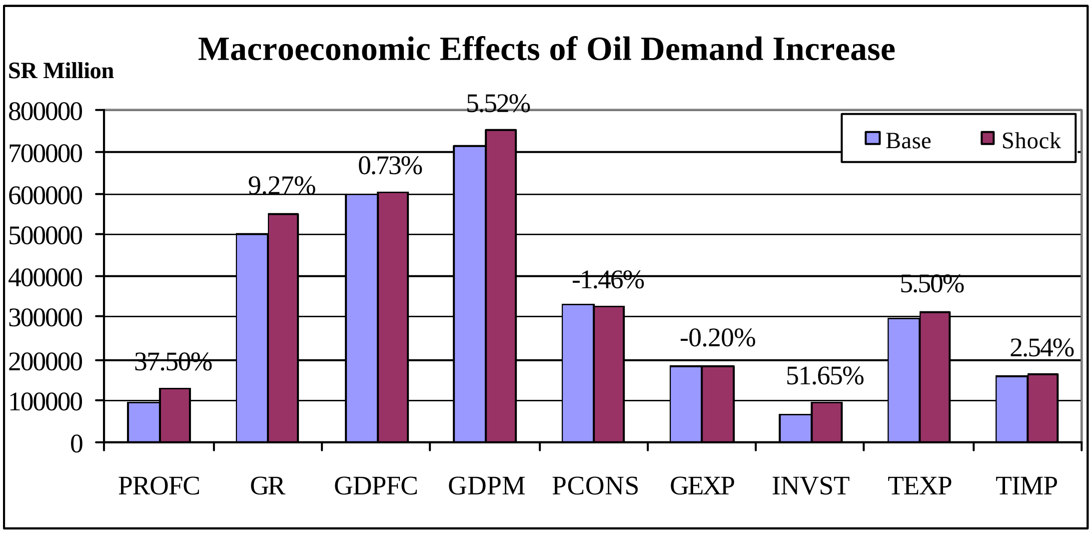
Variables	Base	Shocked	% change
Oil Price	1	1.072	7.21
PROFC	92884	127808	37.50
GR	503948	550665	9.270
GDPFC	599287	603660	0.73
GDPM	714552	754021	5.52
PCONS	331113	326271	-1.46
GEXP	183805	183434	-0.20
INVST	62730	95131	51.65
TEXP	297539	313897	5.50
TIMP	160635	164712	2.54

Source: Simulation results

Key variables:

PROFC: Oil profit
GR: Government revenue.
GDPF: GDP evaluated at factor price
GDPM: GDP evaluated at market price
PCONS: Private consumption
GEXPR: Government consumption
INVST: Investment
TEXPT: Total export
TIMP: Total import

Figure 6.1 Macroeconomic Effects of Increase World Oil Demand by 5%, (SIM-1)



Source: Simulation results

Key variables:

PROFC:	Oil profit
GR:	Government revenue.
GDPF:	GDP evaluated at factor price
GDPM:	GDP evaluated at market price
PCONS:	Private consumption
GEXPR:	Government consumption
INVST:	Investment
TEXPT:	Total export
TIMP:	Total import

Table 6.2 Price and Volume Effects of Increase World Oil Demand by 5%, (SIM -1)

	Price Change %							Volume Change (%)				
	PM	PE	PD	PQ	PX	PD/PM	PD/PE	QM	QE	QD	QQ	QX
AGRI	0	0	-4.00	-3.60	-4	-0.04	-0.04	-9.07	5.91	-0.44	-1.47	-0.40
CRDO	-	7.2	68.20	68.20	17.10	0.00	0.57	-	1.46	-4.86	-4.86	0.38
REFI	0.00	0	1.00	1.00	0.40	0.01	0.01	-5.89	-9.79	-8.45	-8.42	-9.28
MANF	0.00	0.00	1.10	0.60	1.00	0.01	0.01	2.41	-2.48	-0.80	0.66	-1.05
UTIL	0	-	6.30	6.30	6.30	0.06	0.00	7.70	-	-4.17	-4.17	-4.17
CONST	0	0	35.70	34.40	35.60	0.36	0.36	88.42	-33.28	5.48	7.48	5.33
TRDS	0	0	-0.20	-0.20	-0.20	0.00	0.00	-0.72	0.03	-0.30	-0.35	-0.29
NTRDS	-	-	-0.60	-0.60	-0.60	0.00	0.00	-	-	-0.21	-0.21	-0.21
Total	0	1.20	13.44	13.26	6.95	0.13	0.12	2.50	-0.21	-0.24	0.21	-0.23

Source: Simulation results
PD/PM= [(PD1/PM1-PD0/PM0)/PD0/PM0]*100
PD/PE= [(PD1/PE1-PD0/PE0)/PD0/PE0]*100
1 for shock value; 0 for base value

Key variables:
PM: Import price; PE: Export price; PD: Domestic price; PX: Output price; PQ: Composite price; QM: Import commodity; QE: Export commodity; QD: Domestic commodity; QQ: Composite commodity; QX: Output commodity.
AGRI: Agriculture; CRDO: Crude oil; REFI: Refinery; MANF: Manufacture; UTIL: Utility; CONST: Construction; TRDS: Trade service; NTRDS: Non-trade service

On the other hand the shock of oil demand shifts up the relative domestic-import price ratios (PD/PM) by 0.13%, which in turn triggers substitution between imports and domestically produced goods. Johns (2006) concludes that the increase in domestic price could result in some substitution away from domestic purchases resulting in reduced share of domestic consumption to the cheaper import purchases. In a sense the decrease in the imported good price index would increase the value of the relative price index and cause a decrease the domestic market share of total goods utilisation.

Import volume (QM) increase by 2.5% while domestic production for domestic sales (QD) declines slightly by -0.24%. The expansion in import commodities and decline in domestic commodities slightly increases the total commodities available in the domestic market or composite commodities (QQ) by 0.21%. The increase of import commodities also negatively affect output volume (-0.23%).

The effects vary considerably across sectors, triggering reallocation of output. The effects are largely due to the differences in the sectoral structure of imports and exports and the trade elasticities. The differentiated sectoral results especially on factor prices, contribute largely to the varied effects across household groups.

Agriculture (AGRI) and refinery (RIFI) realise a significant drop in imports volume (-9.07% and -5.89% respectively) while imported trade services volume (TRDS) marginally decline (-0.72%). However, manufacturing (MANF), utility (UTIL) and construction (CONST) experience progress in import volume (2.41%, 7.70% and domestic sales (PD) the latter increases by 13.44%. The net effect increases the 88.42%[25] respectively). Export volumes on the other hand rise in the (AGR), crude oil

[25] The large changes in percentage terms can be attributed to the small values of the estimates in addition. Since the

(CRDO) and (TRDS) sectors by 5.91%, 1.46% and 0.03 respectively while the (REFI), (MANF) and (CONST) sectors suffer contractions of -9.79%, -2.48% and -33.28% respectively. The manufacturing sector is considered an important sector. The importance of this sector comes from being a major contributor to the total import value (66.65%) as well as total intermediate input value (19.58%). So, the results on manufacturing needs further explanation, in particular the results on the sector's imports (QM), domestic production (QD) and the composite goods (QQ). They are no changes in its import prices or negligible decline compare with the increase in domestic price (1.10%). Thus, one would expect that the relative price change favouring import volumes (2.41%) would lead to a reduction in domestic production (-0.80%). The net effect is a slight expansion of (QQ) by 0.66%.

iii. Factor Market Effects

I assume that sectoral capital and non-Saudi labour are immobile (fixed). Therefore, any change in production can only come from a reallocation of Saudi labour among sectors. Unlike capital, Saudi labour is free to move from one sector to another as oil demand increased. The results on capital-labour ratios (CAP/LAB) are important in assessing sectoral labour movements, Table 6.3 reports factor effects. The increase of oil demand results in increase overall average rental rate of capital (0.56%) but fall the average wage rate of aggregate labour (-1.25%).

Across the sectors, however, the results vary. For example, in the sectoral return to capital, two sectors indicate an increase: crude oil (7.75%) and construction (121.58), the rest show a decline. As a result, these changes trigger factor substitution in favour of

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estimates are relatively small, any change due to the shock effects is magnified.

labour. It is worthy to note that in terms of labour, there is a tendency for the demand for labour to be pulled up in two sectors: crude oil (6.80%) and construction (19.15%), whereas the demand for labour in the remaining sectors indicates a decline.

In sum, the results of SIM-1 indicate that the crude oil and construction sectors benefit most from both the effects of labour movement and output reallocation. Furthermore, there are indications that show the substitution between capital and labour favours Saudi labour over non-Saudi labour since non-Saudi labour is fixed by assumption.

iv. Households Income and Consumption Effects

In discussing the effects of increase oil demand on household income, consumption and disposable income one is reminded of the closure rule used in this particular experiment, saving-driven investment. Saving is fixed and investments allow

Table 6.3 Factor Market Effects (SIM-1)

	Factor Intensity (CAP/LAB)		% Change in return to capital	% Change in Labour Demand		
Variable	Base	Experiment	Price	Aggregate Labour	Saudi Labour	Non-Saudi Labour
AGRI	0.13	0.13	-5.95	-1.95	-3.49	0
CRDO	0.55	0.52	7.75	6.80	10.57	0
REFI	0.16	0.21	-83.13	-25.72	-82.69	0
MANF	0.10	0.10	-14.20	-3.83	-11.95	0
UTIL	0.03	0.03	-14.82	-7.74	-12.58	0
CONST	0.05	0.04	121.58	19.15	127.38	0
TRDS	0.04	0.04	-3.61	-0.65	-1.08	0
NTRDS	0.01	0.01	-3.17	-0.25	-0.64	0
Total			0.56			0
Average wage				-1.25	-2.94	.35

Source: Simulation results

adjustment to clear the market; factor price "PF" for Saudi labour is flexible but fixed for non-Saudi labour by assumption.

As summarised in Table 6.4, the main source of household income is factor income. Overall factor income (which includes capital income to Saudi households) experiences a contraction of -1.68%. Across factors of production, overall labour income increases by 1.15% while Saudi labour and capital declines by -2.55% and -4.15% respectively which results in a decline in Saudi household income by 1.88%. However, non-Saudi labour income registers an improvement and account for 4.56%. The net effect is a marginal decline in total income of household by -0.94%. The negative effects of the total household income are reflected in a decline in total consumption and expenditure of -1.46% and -1.46% respectively. Overall disposable income contracts as well (-1.30%). Across household the situation is varied, consumption decline for Saudi household (-2.87%) but expansion for non-Saudi households (3.81%).

v. Household Welfare Effects

Table 6.4 also includes the results of household welfare measured by equivalent variation[26] (EV). Household income is affected by the factor income as noted earlier. Welfare effects across household show that Saudi household welfare is worse off by (-2.87%) due to the decline in Saudi household income (i.e. decline in Saudi labour income and capital income), while non-Saudi household welfare is better off (3.81%) due to the expansion in non-Saudi household income as I mentioned earlier, the net effect is that overall welfare loss (-1.46%).

[26] The computation of EV is explained in detail in chapter 5.

Table 6.4 Household Income and Consumption Effects

% Change in:	Total	Non-Saudi	Saudi
Labour income	1.15	4.56	-2.55
Capital income	-4.17	0	-4.17
Household Income	-0.94	3.76	-1.88
Consumption	-1.46	3.81	-2.87
Expenditure	-1.46	3.76	-2.86
Disposable Income	-1.30	3.76	-2.86
Welfare	-1.46	3.81	-2.87

Source: Simulation results

6.1.2 Second Simulation (SIM-2)

To carry out this simulation, the investment-saving closure rule will be modified to a new situation and provide new results. Investment is fixed and saving is flexible to clear the market. This simulation shows to what extent closure rule effect the result.

i. Macroeconomic Effects of Increase World Oil Demand by 5%

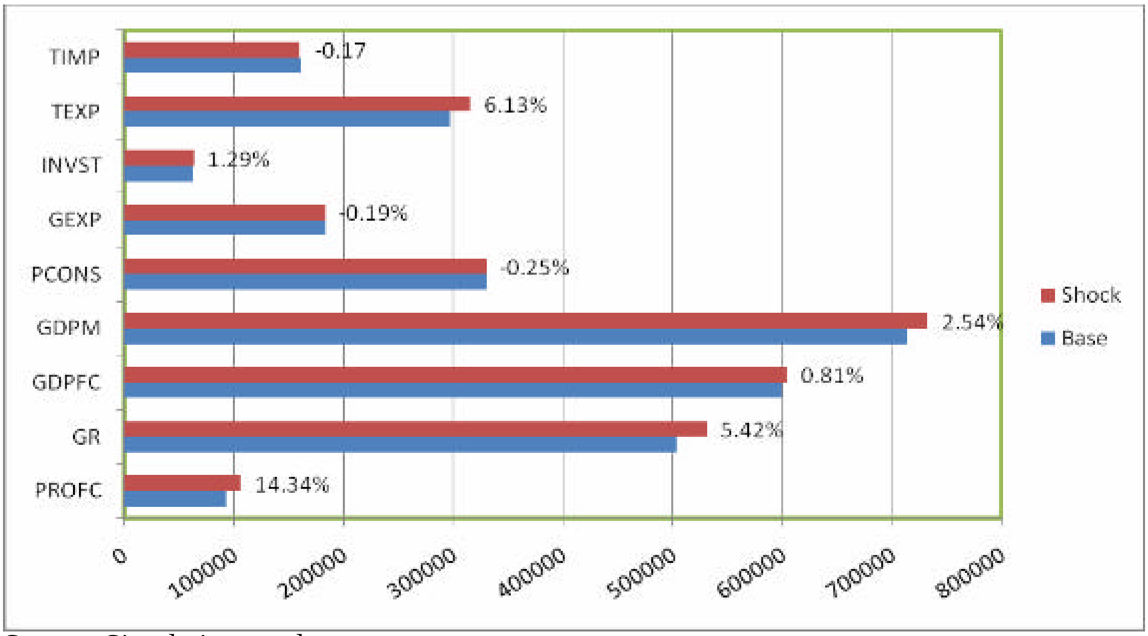
Table 6.5 and Figure 6.4 summaries the impact of increasing oil demand by 5% on selected macroeconomic variables. Increased oil demand would increase oil prices by 7.45% and total exports register progress (6.13%) which results in a significant improvement in oil profits (14.34%), the latter reflected in progress in government revenue (5.42%). The improvement in GDP components turn in an increase in GDP at market price by 2.54% and a minor increase in factor price by 0.81%. However, government and private consumption experience a minor decline by -019% and -0.25% respectively. The progress is realized among GDP components compare to the first simulation (flex investment and fix savings).

Table 6.5 Macroeconomic Effects of Increase World Oil Demand by 5%, (SIM-2)

Variables	Base	Shocked	% change
FROFC	92884.4	106206.762	-0.81
GR	503948	531268.266	5.42
GDPFC	599287	604130.738	0.81
GDPM	714552	732710.954	2.54
PCONS	331113	330273.945	-0.25
GEXP	183805	183464.247	-0.19
INVST	62730	63539.12	1.29
TEXP	297539	315789.498	6.13
TIMP	160635	160355.857	-0.17

Source: Simulation results

Figure 6.3 Macroeconomic Effects of Increase World Oil Demand by 5%, (SIM -2)



Source: Simulation results

i. Effect on Prices and Volumes of Commodities

The price and volume effects of SIM-2 are presented in Table 6.6. The shock of oil demand turns into progress in export price in particular oil price which increase by 7.5% which encourage crude oil export to increase by 0.70% and since the oil represent about 90% of total exports the latter increase by 6.13% as a component of GDP.

Average domestic import price increase by 1.67% which negatively influence import goods causing a decline by 0.17%. This situation result in domestic price and composite prices to sift up by 3.05% and 3.04% respectively which discourage consumers to purchase domestic commodities casing a decline in theses commodities by -0.18% and -0.18% respectively.

The effects import prices vary across sectors causing reallocation of output. The effects are largely due to the differences in the sectoral structure of imports and exports and the trade elasticicities.

Refinery, utility and construction realize an expansion in import volumes (5.23%, 2.80% and 0.31 respectively) while the rest decline. Export volume on the other hand rises in agriculture, crude oil and trade sectors by 0.48%, .70%, and 0.32% respectively while the remaining sectors suffer contraction. The decline is largely attributed to domestic and export relative prices of these sectors.

Table 6.6 Price and Volume Effects of Increase World Oil Demand by 5%, (SIM -1)

Variable	Price Change %							Volume Change (%)				
	PM	PE	PD	PQ	PX	PD/PM	PD/PE	QM	QE	QD	QQ	QX
AGRI	-3E-13	0	-0.30	-0.30	-0.3	0.108	0.11	-0.69	0.48	0.002	-0.08	0.005
CRDO	0E+00	7.5	21.70	21.70	9.90	0.000	0.00	NON	0.70	-1.346	-1.35	0.35
REFI	-1E-13	0.00	1.10	1.10	0.40	0.059	0.06	2.53	-2.26	-0.618	-0.58	-1.64
MANF	1E-11	0.00	0.10	0.00	0.10	0.001	0.00	-0.05	-0.42	-0.291	-0.18	-0.31
UTIL	0E+00	NON	2.10	2.10	2.10	0.021	0.02	2.80	NON	-1.224	-1.22	-1.22
CONST	3E-08	0	0.20	0.20	0.20	0.002	0.00	0.31	-0.33	-0.046	-0.04	-0.05
TRDS	2E-11	0	-0.20	-0.20	-0.20	-0.002	0.00	-0.45	0.32	-0.021	-0.07	-0.01
NTRDS	0.000	NON	-0.30	-0.30	-0.30	0.000	0.00	NON	NON	-0.001	0.00	0.001
Total	1.667	1.25	3.05	3.04	1.49	5.336	5.34	-0.17	0.26	-0.178	-0.18	-0.06

Source: Simulation results

PD/PM= [(PD1/PM1-PD0/PM0)/PD0/PM0]*100
PD/PE= [(PD1/PE1-PD0/PE0)/PD0/PE0]*100

iii. Factor Market Effects

The results are presented in Table 6.7. As mentioned earlier the study assumes that the sectoral capital and non-Saudi labour are fixed while Saudi labour is flexible. Therefore, any change in production can only come from a reallocation of Saudi labour among sectors. Table 6.8 shows that the shock of oil demand results in a decrease of the overall average rental rate of capital (-28.61%), average wage rate of aggregate labour falls as well (-1.91%). Across households, Saudi labour and non-Saudi labour fall by -0.46% and -0.04% respectively.

Across sectors, however, only the crude oil sector return to capital grows by 9.20%, the rest experience contraction. As a result these changes trigger factor substitution in favour of labour. So there is an increase in demand for labour in agriculture, crude oil, and non-trade sectors by 0.04%, 9.68%, and 0.002% respectively.

In sum, the results of the experiment indicate that the agriculture, crude oil, and non-trade sectors are the most likely to benefit from both the effects of labour movement and output reallocation. Furthermore, substitution between capital and labour favours Saudi workers over non-Saudi labour.

Table 6.7 Factor Markets Effects, (SIM-1)

Variable	Factor Intensity (CAP/LAB) Base	Factor Intensity (CAP/LAB) Experiment	% Change in return to capital Price	% Change in Labour Demand Aggregate Labour	% Change in Labour Demand Saudi Labour	% Change in Labour Demand Non-Saudi Labour
AGRI	0.13	4.83	-0.40	0.04	0.04	0
CRDO	0.55	0.10	9.20	9.68	9.68	0
REFI	0.16	1.56	-26.10	-25.72	-25.72	0
MANF	0.10	0.07	-4.10	-3.68	-3.68	0
UTIL	0.03	0.13	-4.30	-3.81	-3.81	0
CONST	0.05	0.03	-1.20	-0.75	-0.75	0
TRDS	0.04	0.06	-0.50	-0.05	-0.05	0
NTRDS	0.01	0.01	-0.46	0.002	0.002	0
Total			-28.61			0
Average wage				-1.91%	-0.46%	-0.035

Source: Simulation results

ii. Households Income and Consumption Effects

It is worthy to remember with the closure rule used in this particular simulation, it is investment-driven in which investment is fixed and saving is flexible it allows adjustments to clear the market. Table 6.8 summarizes the effects of household income, consumption and disposable income.

Across households, Saudi labour and non-Saudi labour income decline by -0.46% and -1.29% respectively, capital income declines as well (-3.10%). The decline in factor income implies a falls in household income (-1.16%) result in a decline in household consumption by -0.25%. As a result total disposable income and expenditure also suffer contractions (-17.55% and -18.76% respectively).

iii. Household Welfare Effects

Table 6.8 also includes the results of the equivalent variation, (EV). The closure rule would affect the two households welfare. Saudi household welfare experience remarkable loss because savings are flexible (-0.69%) while non-Saudi households significantly gain (0.14%). The net effect worsen the overall welfare (-0.11%).

Table 6.8 Household Income and Consumption Effects, (SIM -1)

% Change in:	Total	Non-Saudi	Saudi
Labour income	-0.89	-1.29	-0.46
Capital income	-3.10	0	-3.10
Household income	-1.16	-1.06	-1.18
Consumption	-0.25%	-0.69%	-0.14%
Expenditure	-0.25	-0.73	-0.13
Disposable income	-1.64	-1.06	-1.82
Welfare	-0.11	-0.14	-0.69

Source: Simulation results

It is clear from the results of the two simulations that the closure rule plays a crucial role in CGE models base on the assumptions of closure rule in a particular experiment.

6.1.3 Note about results of SIM-1 and SIM2:

One would wonder about the result of the two simulations. Despite the increase in oil revenue and government revenue, public and private experience contraction in consumption but investment increase. This result contradicts our expectations but the phenomenon may happen in reality, China for example, experiences the same situation in the last years. Xu(2010), refers to different studies discuss this issue.

Luo (2007) argued that low consumption accompanied by high investment is the norm of economic performance in China at present, and government should not regard the proportion of investment and consumption as objectives of adjusting macroeconomic policy. He believes that further research should focus on both reasons why the consumption rate has decreased continuously and policies and measures that can stimulate consumption. However, most scholars believe that China's consumption rate is significantly low in recent years, and there is an ongoing debate about the reasons. Zheng (2007) stated that low-income and high investment rate is the main reason for the low consumption rate in China. Wu and Qian (2004) believe that the widening income distribution gap could lead to reduce consumption in urban households, whereas the decline of the consumption rate may restrict the development of the national economy. Xu (2005) argues that the main reason for the decline of China's consumption rate was that the average propensity to consume of Chinese households dropped too fast. Researchers (Song 1999; Zang and Pei 2004) analyzed the consumption behaviour of Chinese households based on the precautionary savings theory, and suggested that the uncertainty of future income was the main reason for the low consumption rate. Wan et al. (2001) used standardized econometric model to analyze data and found that uncertain factors had a significant effect on consumption, and thus a high proportion of consumers with the characteristic of liquidity constraint was conducive to the decline of consumption rate in China. Saudi Arabia economy would work more or less as the Chinese economy.

On word both scenarios explain to what extent oil demand shock affects economy, given heavy reliance on oil revenue to enable the country achieves development plans. In addition show the importance of closure rule in the analysis.

6.1.4 Conclusion

This experiment examines a 5% increase in world oil demand and its effects on oil prices and the ultimate effects on the Saudi economy. The model is sensitive to closure rules changes. So in this experiment I carry out two simulations based on the type of investment-savings closure to explore the possible changes on the Saudi economy.

The first simulation in which I assume investment is flexible and savings are fixed, the findings indicate an improvement in most variables. Oil price increases as a result of oil demand shock, result in expand total exports due to the fact that oil exports constitutes about 90% of total exports, eventually oil profit increased and government revenue progressed. Due to the effect of the closure rule (saving is fixed) on the result in general and particularly on household, welfare effect shows that households are worsen off.

In the second simulation I assume savings are flexible and hold investments fixed. The results indicate that despite the progress in most of variables such as oil price, total exports, oil profit and government revenue, there is a contraction in income, consumption and household welfare but less than the first simulation.

6.2 Second Experiment

6.2.1 The Model Closure Rule

I just remind about the closure rule which I use in this experiment, more detail was discussed in chapter 5.

Government Account Closure

Government consumption is held fixed.

Investment-saving closure

The study adopts investment-saving driven closure. Here investment is kept fixed and savings are adjusted for Saudi households to ensure that savings equal investments (neoclassical assumption). It is a more realistic approach to the Saudi economy because the majority of people do save part of their income. For non-Saudi households savings remain fixed

Factor closure

In the labour market, Saudi labour is assumed to be mobile across sectors, fully employed (i.e. there is no unemployment). Factor price distortion is fixed, while factor price is flexible to clear the market.

Non-Saudi labour is assumed to be sector-specific, immobile and fully employed. Factor price is fixed and factor price distortion is flexible to clear the market.

Capital is sector-specific immobile, factor price is fixed and factor price distortion is flexible to clear the market.

Exchange Rate closure

To ensure the balance of payments equilibrium, the exchange rate is treated as exogenous (i.e. the currency in Saudi Arabia is pegged to the US dollar) and the balance of payments is allowed to adjust endogenously.

6.2.2 Justification carrying out Experiment two

Foreign trade is significant for Saudi Arabia because of the unique position of Saudi Arabia in the world economy. Key industries such as petrochemical manufacturing currently export most of their output (chemical and plastic products with a value of S.R 62739 million at a rate of 5% of the total export value in 2008). Similarly, also imports play an important role in Saudi Arabia economy. Machines appliances and electrical gadgets had the highest imports value during 2008, which reached S.R 117318 million at a rate of 27% of the total import value then, transport equipment with a value of S.R 77620 million at a rate of 18% of the total imports value. Increased availability of high quality imports has improved the welfare of final consumers and the efficiency of domestic producers.

Membership of WTO would be an economically important step to further support Saudi Arabia in integration into global economy. While the country officially applied for membership in 2005, policy-makers, economists and representatives of the business community still discuss controversially about potential benefits and costs of WTO accession. On one hand, it is argued that improved market access for Saudi Arabia goods to markets such as USA, European Union(EU), China and India will increase profits of Saudi Arabia exports. Furthermore, efficiency and welfare gain from reduced tariffs on imports as a result of WTO accession.

Al-Sadoun points out:

"On the benefits side, the removal of trade barriers called for by WTO bylaws will allow Saudi petrochemical producers to offer lower prices to tariff-protected

markets, such as the EU, US and Japanese markets. The tariff reduction in these economies may induce a sizable increase in Saudi petrochemical exports to those economies, depending on the response of supply and demand to the lower prices resulting from tariff reduction. For instance, tariffs on polymers (polyethylene, polystyrene, PVC, polypropylene) in the EU are to be reduced by approximately half, from 12.5 percent to 6.5 percent".(Monday 12 December 2005, Arab News).

On the other hand, critics are concerned about increase international competition that push domestic firms out of the market, and about the ability of Saudi Arabia economy to fully enjoy the benefits of WTO membership in general.

This experiment attempts to quantitatively assess economy-wide implications of Saudi Arabia accession to WTO. Based on standard CGE framework we explicitly study the consequences of the dropping of tariffs. Our main finding is that WTO membership has significantly increase consumer welfare and GDP of the Saudian economy.

In this experiment, the model is used to determine the effects of eliminating import tariffs simulation levels. Three simulations are undertaken and this involved dropping tariffs for all protected commodities. Since trade liberalisation worsens the government fiscal position, therefore, the trade liberalisation process should accompany appropriate economic measures in order to counteract the adverse effects on government revenue due to the reduction in custom duties.

The revenue lost from trade liberalisation is replaced in two simulations which are both revenue neutral, they differ, however, in how the government revenue is sustained. On one hand applying indirect tax (sales tax) for all sectors to keep the government deficit constant, on the other hand, trade liberalisation is accompanied by imposing direct tax. However, in order to investigate the robustness of the model a sensitivity analysis is carried out. The three simulations can be summarised as follows:

First Simulation (SIM-1): This scenario involves simulating the tariff abolition without compensation.

Second Simulation (SIM-2): The compensatory tax is imposed through indirect (sales) tax on output. Although this experiment is revenue-neutral, the additional indirect tax in effect replaces the distortion coming from tariff rates with distortion from indirect output tax.

Third Simulation (SIM-3): This scenario is the same as that used in SIM-2 except the compensatory tax is income tax. An increasing share of income tax revenue is observed during the period in which there is a declining share of tariff revenue. In effect, this experiment is revenue-neutral.

6.2.3 First Simulation (SIM-1):

Removing all tariffs for the fiscal year 2000, is carried out to assess the economic impact of tariff removal on macroeconomic indicators, sectoral output and employment, as well as the impact on household consumption in Saudi Arabia, without maintaining neutrality of government revenue while there is no compensating fiscal mechanism to replace the tariff revenue.

Tariff income is not very large in Saudi Arabia, only about SR9,650 million, making up approximately 1.9% of total government revenue. So the results indicate that there will not be much of an impact in absolute terms from eliminating this tax. However, different sectors will be affected according to their amount of tariff and capital-labour intensity.

i. Macroeconomic Effects of Tariff Abolition

The effects of trade liberalisation on national income aggregates are presented in Table 6.11 and Figure 6.3. Tariff abolition reduces the price of imported commodities relative to domestic goods, thereby causing a shift of the demand curve towards imported goods and away from domestic production. Specifically, the tax reforms (tariff abolition) affect the aggregate macroeconomic condition which includes: Gross Domestic Product at factor cost (GDPFC); Gross Domestic Product at market price (GDPFC); private consumption (PCONS), government expenditure (GEXP); investment (INVST); exports (EXP) and imports (IMP).

GDP (at factor cost) increases by 3.60%, meanwhile, real GDP evaluated at market price marginally increases by 0.78%. On the other hand tariff elimination affect relative prices which affects overall domestic import prices by 3.93% which in turn increase total imports by 13.11%. Interestingly, total export experiences a minor decline which account for -0.07%.

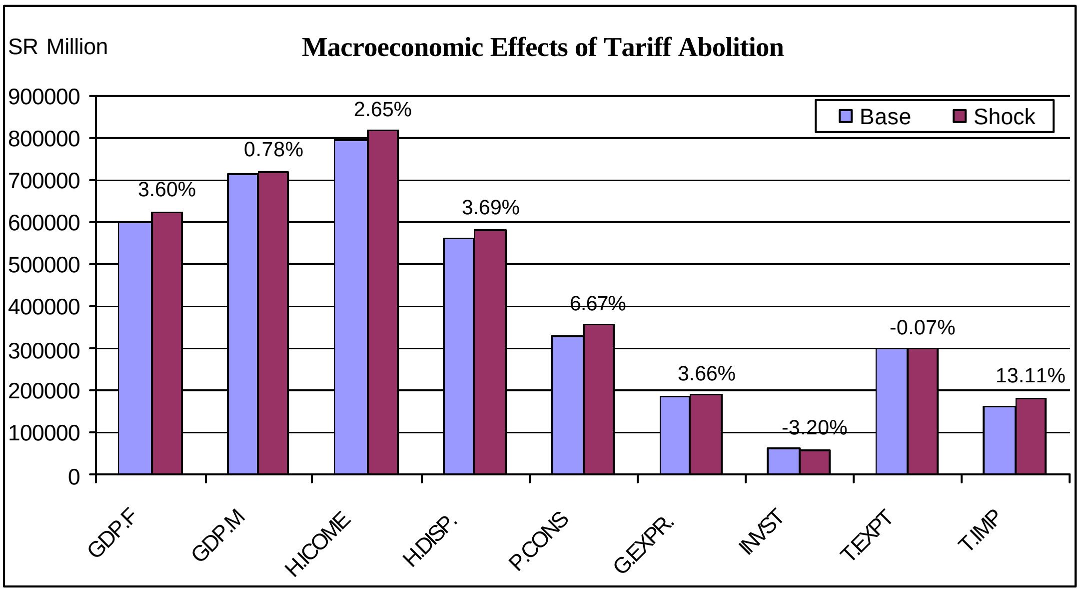
Aggregate private consumption showed an increase of 6.67% due to the decline in domestic prices and increases in household income as is discussed at the end of this section. Government expenditure experiences an expansion (3.66%) due to the decline in composite price (PQ). In terms of government finance, government revenue decreases by 3% as immediate consequences of the tariff drop. However, the substantial increase in private consumption as mentioned above results in a decline in the household savings account of 7.93% since the latter is flexible by assumption for Saudi households.

Table 6.9 Macroeconomic Effects of Tariff Abolition without Compensation, (SIM -1)

Variable	Base	Shock	%
GDPFC	599287	620876.581	3.60
GDPM	714552	720094.491	0.78
PCONS	331113	353208.221	6.67
GEXP	183805	190535.222	3.66
INVST	62730	60721.722	-3.20
EXP	297539	297320.567	-0.07
IMP	160635	181691.24	13.11

Source: Simulation results.

Figure 6. 3 Macroeconomic Effects of Tariff Abolition without Compensation, (SIM -1)



Source: Simulation results.

Despite the results indicate that tariff elimination, liberalisation increases GDP, total investment decline by -3.20.

ii. Effect on Prices and Volumes of Commodities

The price and volume effects of SIM-1 are presented in Table 6.12. Tariff elimination results in an overall reduction in the domestic price of imports (PM) by -3.93%. Similarly, the overall composite price (PQ) marginally declines by -0.48%, overall domestic price (PD) marginally increase by 0.1%.

On the other hand the drop tariff results in shifts in the relative domestic-import price ratios (PD/PM) by 0.04, which in turn triggers substitution between imports and domestically produced goods. For example, import volume (QM) increases by 13.24% while domestic production for domestic sales (QD) slightly declines by 0.001%.

Taken together these changes result in an increase in the total goods available in the market by 2.31% improvement in the composite goods (QQ). On the whole,

tariff abolition results in increased import quantity because of lower import prices, an increase in total quantity of goods available in the market due to higher imports. However, production for domestic sales (QD) marginally declines because of substitution effects.

The effects vary considerably across sectors triggering reallocation of output. The effects are largely due to the differences in the sectoral structure of imports and exports, tariff rate and the trade elasticities. The differentiated sectoral results, especially on factor prices, contribute largely to the varied effects across household groups.

Agriculture, refinery and manufacture realise a significant drop in import prices (-7.86%, -7.80%, -7.85% respectively). However, there is no change in import prices in the rest sectors (no tariffs levied). The sectoral effects on import volumes are due to the differentiated effects on import prices and on the differences in the import elasticities, the Armington elasticities.

Taking these factors together, the refinery sector registers the largest increase in import volume (30.36%) followed by agriculture (28.45%), manufacture (14.72%), utility (8.20%) and trade (7.86%), while the construction sector only shows an increase of 0.81%. Export volume on the other hand rises in the refinery and manufacturing sectors by 0.05% and 2.74% respectively, but the other sectors suffer a contraction in exports.

Manufacturing is an important sector. The importance of this sector comes from being a major contributor sector to the total import commodities (66.65%) as well as total intermediate input (19.58%). So the results on manufacturing needs furt explanation, in particular the results on the sector's imports (QM), domestic production (QD) and the composite (QQ). It can be observed that the drop in its import prices is larger than in its domestic prices, (-7.85% and -2.70%, respectively). It would be expected that this relative price change favours imports (14.72%) leading to a reduction in domestic production (-1.43%) and improved level of composite goods by 5.82%.

Table 6.10 Price and Volume Effects of Tariff Abolition without Tariffs Compensation

Variable	Price Change %							Volume Change (%)				
	PM	PE	PD	PQ	PX	PD/PM	PD/PE	QM	QE	QD	QQ	QX
AGRI	-7.858	0.00	3.3	1.8	3.19	0.122	0.033	28.446	-4.89	-0.13	3.06	-0.15
CRDO	NON	0.10	-12.4	-12.4	-2.04	NON	-0.125	NON	-0.35	0.64	0.64	-0.18
REFI	-7.798	0.00	0.9	0.8	0.30	0.094	0.009	30.360	0.05	1.36	1.66	0.55
MANF	-7.852	0.00	-2.7	-5.2	-2.35	0.056	-0.027	14.717	2.74	-1.43	5.82	-0.79
UTIL	0	NON	3.2	3.2	3.10	0.032	0.000	8.2	NON	1.95	1.95	1.95
CONST	0	0.00	0.4	0.4	0.40	0.004	0.004	0.814	-0.67	-0.02	0.01	-0.02
TRDS	0	0.00	3.9	3.4	3.66	0.039	0.039	7.864	-5.33	0.28	1.16	0.17
NTRDS	NON	NON	4.2	4.2	4.03	NON	NON	NON	NON	0.37	0.37	0.37
Total	-3.93	0.017	0.1	-0.475	1.34	0.042	1.001	13.242	-0.16	-0.001	2.31	-0.04

Source: Simulation results.

PD/PM= [(PD1/PM1-PD0/PM0)/PD0/PM0]*100
PD/PE= [(PD1/PE1-PD0/PE0)/PD0/PE0]*100

iii. Factor Market Effects

The study assumes that sectoral capital and non-Saudi labour are fixed. Therefore, any change in production can only come from a reallocation of labour between sectors. Unlike capital, Saudi labour is free to move from one sector to another as tariffs are eliminated. The results on capital-labour ratios are important in assessing sectoral labour movements. The results are presented in Table 6.13.

The elimination of tariff results in an increase in the average rental rate of capital (8.63%) and improves the average wage rate of aggregate labour (4.46%). Across households, Saudi and non-Saudi labour average price increases by 5.88% and 3.13% respectively.

Across sectors however, the results vary. For example, in the sectoral return to capital, six sectors indicate an increase: crude oil (0.30%), refinery (16.30%), utility (11.90%), construction (4.90%), trade (6.0%) and non-trade (6.50%), the rest show a decline. As a result, these changes trigger factor substitution of capital in favour of labour. It is worthy to note that in terms of labour there is a tendency for the demand for labour to be pulled up in three sectors: manufacturing (107.49%), construction (324.05%), and trade services (44.32%), whereas the demand for labour in the rest of the sectors indicates a decline.

In sum, the results of the experiment indicate that the manufacturing, construction, and trade services sector benefit most from both the effects of labour movement and output reallocation.

Table 6.11 Factor Market Effects without Tariff Compensation, (SIM-1)

Variable	Factor Intensity (CAP/LAB)		% Change in return to Capital	% change in labour Demand		
	Base	Experiment		Aggregate Labour	Saudi Labour	Non-Saudi Labour
AGRI	0.33	0.13	-96.10	-93.12	-1.34	0
CRDO	0.10	0.57	0.30	-1.27	-4.73	0
REFI	1.16	0.15	16.30	-16.45	10.42	0
MANF	0.07	0.10	-4.30	107.49	-9.14	0
UTIL	0.13	0.03	11.90	-81.15	6.27	0
CONST	0.03	0.05	4.90	324.05	-0.33	0
TRDS	0.01	0.04	6.00	44.32	0.65	0
NTRDS	0.07	0.01	6.50	-4.91	1.15	0
Total	0.18	0.07	8.63	-24.26	3.39	0
Average Wage				4.46	5.88	3.13

Source: Simulation results.

iii. Households Income and Consumption Effects

What are the effects on the sources of income of households? As the results indicated in Table 6.13 above, the average wage rises in total and across households, reflected in increase in total labour income by 5.13% Table 6.14. Across labour, Saudi and non-Saudi labour improve as well (5.30% and 4.97% respectively). The progress in labour income turns in expanding in total household income (2.66%) and among households Saudi and non-Saudi (2.37% and 4.10% respectively). Disposable income experiences an improvement (3.69%) due to the positive effects of household income. With regards to household consumption there are two major factors namely domestic prices and household income. The result shows progress in total consumption (6.67%).

Across households both Saudi and non-Saudi households enjoy an expansion in consumption of 7.49% and 3.63% respectively.

With respect to household consumption across sectors, Table 6.15 shows different sectors and different levels of consumption. Crude oil consumption realizes the highest increase account for 114.56% since this sector is subsidised by the government, followed by the manufacturing sector (12.57%) and construction (6.31%), the lowest sector is the non-trade sector (2.49%).

iv. Household Welfare Effects

Table 6.14 also includes the results of the equivalent variation, (EV). The welfare analysis indicates that tariff elimination improves overall welfare (6.67%). As such the tariff reduction program is welfare-improving. The positive welfare effects come from the improvement in real income and consumption. Across households the results

Table 6.12 Household Income and Consumption Effects of Tariff Abolition without Compensation, (SIM-1)

% Change in:	Total	Non-Saudi	Saudi
Consumption	6.67	3.63	7.49
Expenditure	6.67	4.10	7.36
Labour income	5.13	4.97	5.30
Household income	2.66	4.10	2.37
Disposable income	3.69	4.10	3.56
Consumer price index	0.20	0.45	-0.116
Household welfare	6.67	3.63	7.49

Source: Simulation results.

Table 6.13 Consumption Effects of Tariffs Abolition across Sectors without Tariff Compensation, (SIM-1)

Variable	Base	Shock	%
AGRI	38126	39968.56	4.833
CRDO	1089	2336.606	114.564
REFI	6582	6973.734	5.952
MANF	118859	133799.7	12.570
UTIL	4778	4952.728	3.657
CONST	378	401.868	6.314
TRDS	146616	151035.4	3.014
NTRDS	14685	15050.29	2.488
Total	331113	354519	7.069

Source: Simulation results.

indicates that Saudi and non-Saudi households are better off (7.49% and 3.63% respectively).

v. Note on the result:

In this experiment exports experience contraction, this result is consistent with Habeeb (1991) in his study about diversification policy in Saudi Arabia. He analyses the effect of free trade on the Saudi Economy and come up with exports experience a decline and private consumption increase. The author attributes the decline in exports to the fact that most of Saudi infant industries can’t compete in world market and this may support the private sector’s demand for short term protection. The government urges the private sector to invest in industries when it is possible to take advantage of economies of scale which decreases the cost and enables domestic producers to compete in the world market. He mentioned also that the finding supports the fact that imported goods are a highly competitive with domestic goods either because of higher quality or because of foreign dumping.

In another example from Indonesia, Damuri and Perdana (2003) by looking at the changes in trade balance, the simulation results shows that higher government spending leads to higher imports and lower exports. Furthermore, Abu-Dahesh (2000) examines effect of tariff iberalization (zero tariffs) on Saudi economy the results show that the private consumption experience progress as our results. Factor prices 'in our experiment'vary depend on the demand for labour and capital, prices vary based on whether the sector is intensive labour or capital.

6.2.4 Second Simulation (SIM-2)

In this simulation trade liberalisation is accompanied by imposition sales tax[27] . The sales tax covers the government revenue shortfall from the fall in import duty collection.

i. Macroeconomic Effects of Tariff Abolition with Applying Sales Tax

It is apparent that the macroeconomic impact of tariff removal has a very strong influence on the results. Table 6.16 and Figure 6.4 show the impact on selected macroeconomic variables. When the trade liberalisation measure is accompanied by sales taxes, real GDP declines at factor cost by -1.87% with a much smaller increase of at market price (0.68%) and total exports marginally increase by 0.15%. Tariff elimination influences relative prices as reflected in an significant increase in total imports of 8.92%. However, public and private consumption experience an increase of 2.33% and 4.32% respectively, due to the significant decline in import price and eventually (PQ) and increase (QQ) for manufacturing as a major sector (manufacture import price declines by -7.80% which significantly affects the manufacture composite

[27] Essentially there is no sales tax in Saudi Arabia.

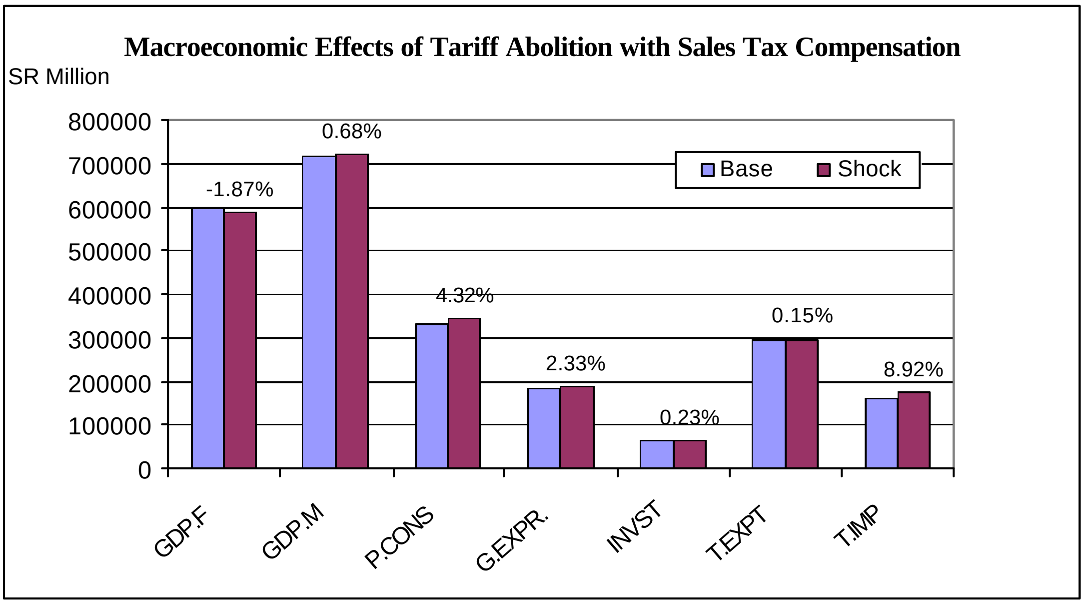
price to declines by -4.05%. There is a minor progress in terms of investment account for 0.23%.

Table 6.14 Macroeconomic Effects of Tariff Abolition and Imposition Sales Tax, (SIM -2)

Variable	Base	Shock	Change %
GDPF	599287	588053.12	-1.87
GDPM	714552	719381.17	0.68
PCONS	331113	345410.93	4.32
GEXPR.	183805	188095.71	2.33
INVST	62730	62874.42	0.23
TEXPT	297539	297969.8	0.15
TIMP	160635	174969.7	8.92

Source: Simulation results

Figure 6.4 Macroeconomic Effects of Tariff Abolition and Imposition Sales Tax, (SIM -2)



Source: Simulation results

ii. Prices and Volumes of Commodities Effects

Table 6.17 reports the effects of tariff elimination accompanied by sales tax on volume and prices of commodities across sectors. Tariff elimination results in an overall reduction in the domestic price of imports (PM) by -3.93%. Overall price of domestic and composite commodities increases by 3% and 4.06% respectively. Across sectors for example, the decline in manufacture import price by -7.9% leads the manufacture composite price to decline by -4%. On the other hand, the tariff drop results in minor progress in the relative domestic-import price ratios (PD/PM) by 0.07. This in turn generates substitution between imports and domestically produced goods. For example, import volume (QM) increases by 9.09% while domestic production for domestic sales (QD) remarkably declines by -0.49%.

Taken together these changes result in an increase in the total goods available in the market as shown by a 1.40% improvement in the composite goods (QQ). At the sectoral level the effects vary considerably across sectors to a reallocation of output. The effects are largely due to the differences in the sectoral structure of imports and exports, and the trade elasticities (Armington elasticity). Agriculture, refinery and manufacturing produce a significant drop in import prices (-7.90%, -7.80%, -7.90% respectively). However, there is no change in import prices in the other sectors (utility, trade and construction) since they are unprotected sectors.

Taking these factors together result in the largest increase in import volume (QM) in refinery (30.26%), followed by agriculture (19.80%), manufacture (11.37%), utility (6.70%) and trade (2.05%), while the construction sector registers an increase of only 0.12%. Export volume on the other hand, rises in manufacturing and crude oil sectors

Table 6. 15 Price and Volume Effects of Tariff Abolition and Imposition Sales Tax, (SIM-2)

Variable	PM	PE	PD	PQ	PX	PD/PM	PD/PE	QM	QE	QD	QQ	QX
AGRI	-7.90	0.00	1	0.7	0.00	0.086	0	19.80	-0.08	-0.02	2.22	-0.02
CRDO	-	-0.10	1.21	21	3.50	-	0.211	NON	0.27	-1.39	-1.39	-0.01
REFI	-7.80	0.00	1.014	3.1	0.50	0.100	0.014	30.26	-2.38	-0.28	0.03	-1.58
MANF	-7.90	0.00	0.964	-4.00	-3.00	0.047	-0.036	11.37	3.55	-1.94	4.05	-1.10
UTIL	0	-	1.036	5.40	3.60	0.036	NON	6.70	NON	-0.25	-0.25	-0.25
CONST	0	0.00	1.001	1.80	0.10	0.001	0.001	0.12	-0.12	-0.02	-0.01	-0.02
TRDS	0		1.009	2.50	0.90	0.009	0.009	2.05	-0.93	-0.37	0.57	0.35
NTRDS	-	-	1.003	2	0.30	-	-	NON	NON	0.36	0.36	0.36
Total	-3.93	-0.017	2.963	4.06	0.74	0.072	1.030	9.09	0.21	-0.49	1.40	-0.11

Source: Simulation results

PD/PM= [(PD1/PM1-PD0/PM0)/PD0/PM0]*100
PD/PE= [(PD1/PE1-PD0/PE0)/PD0/PE0]*100

by 3.55% and 0.27% respectively, but the rest sectors suffer contraction. As I mentioned earlier about the importance of the manufacturing sector, I give more attention to the results on the sector's imports (QM), domestic production (QD) and the composite (QQ). It can be observed that the drop in import prices is large while experiencing a minor increase in domestic prices of -7.90% and 0.96%, respectively. Thus, one would expect that this relative price change favouring imports would lead to a reduction in domestic production. However, the result on domestic production for domestic sales (QD) indicates a decrease of -1.94%, import quantity increases by 11.37%, and composite goods (QQ) for the sector register an increase of 4.05%.

iii. Effects on Factor Market

What happened to the flow of resources across sectors? As I did in SIM-1 I assume that sectoral capital and non-Saudi labour are fixed. Therefore, any change in production can only come from a reallocation of Saudi labour across sectors. Unlike capital, labour is free to move from one sector to another as tariff is eliminated. Table 6.18 shows the results. The elimination of tariff accompanied by a sales tax hurt production factors resulting in a decline in the overall return to capital (-4.69%), the average wage rate of aggregate labour (-2.68%) and across Saudi and non-Saudi labour (-0.13% and -5.21% respectively).

Across sectors however, the results vary. For example, in the sectoral rental rate of capital, other than trade and non-trade services (1.20% and 1% respectively) all sectors experience a decline. The largest fall is seen in the refinery sector (-25%) followed by manufacturing (-12%), while the smallest decline appears in the agriculture

Table 6.16 Factor Markets Effects of Tariffs Abolition and Imposition Sales Tax, (SIM -2)

Variable	Factor Intensity (K/L)		% Change in return to Capital	% Change in Labour Demand		
	Base	Experiment		Aggregate Labour	Saudi Labour	Non-Saudi Labour
AGRI	0.132	0.132	-0.30	-0.11	-0.20	0
CRDO	0.563	0.554	-0.50	1.60	-0.35	0
REFI	0.126	0.169	-25.00	-25.35	-24.94	0
MANF	0.206	0.100	-12.60	105.19	-12.50	0
UTIL	0.006	0.032	-0.90	-81.93	-0.79	0
CONST	0.194	0.046	-0.40	324.09	-0.26	0
TRDS	0.060	0.041	1.20	44.89	1.30	0
NTRDS	0.006	0.132	1.00	-4.92	1.12	0
Total	0.000	0.000	-4.69	0.00	0.00	0
Average Wage				-2.68	-0.13	-5.21

Source: Simulation results.

sector (-0.3%). In terms of labour demand, four sectors: crude oil (1.60%), manufacturing (11.19%), construction (32.09%) and trade (44.89%) indicate an increase in labour demand whereas the other sectors show a decline.

In sum, the results of the experiment indicate that the crude oil, manufacturing, construction and trade sectors benefit the most from both the effects of output reallocation and labour movement.

iv. Households Income and Consumption Effects

What are the effects of drop tariff and applying sales tax on the sources of income of households? Table 6.19 reports the results regarding consumption, expenditure, income, saving, disposable income and welfare change.

Overall labour income slightly decreases by -0.75% as a result of the tariff abolition and the introduction of sales tax. The decline varies among labour groups, the decline in Saudi labour income less than non-Saudi labour income (-0.13% and -1.31% respectively). The assumptions of closure rule affect directly this result (wage for non-Saudi labour is fixed but flexible for Saudi labour). On the other hand, Saudi household's capital income registers a decrease of -3.77%.

This decline in factor income results in a decline in total household income by -1.32%. Across households, Saudi households and non-Saudi households experience a decline of -1.37% and -1.08% respectively. With regard the effects at the level of household consumption, the manufacturing sector affects total consumption as a major sector. Manufacturing composite price (PQ) decline by -4.00%, result in a remarkable increase in consumption from this sector (8%) which increases the total consumption by 4.32%. Across households, Saudi households grow by 5.85% while non-Saudi households fall by 1.40%.

Table 6.20 shows consumption across sectors. The highest consumption comes from the manufacturing sector which increases by 8.84% followed by agriculture (3.76%), construction (2.69%), non-trade (2.46) and the lowest increase of consumption comes from the refinery sector by 1.41%.

v. Household Welfare Effects

The final part in this simulation is welfare change. Table 6.19 also includes the results of equivalent variation (EV). This measure depends on income and the consumer price index and eventually household expenditure to evaluate welfare change. Overall welfare increases by 4.32%. Across households, Saudi household welfare experience

Table 6. 17 Household Income and consumption Effects of Tariffs Abolition and Imposition Sales Tax, (SIM-2)

% Change in:	Total	Non-Saudi	Saudi
Consumption	4.32	-1.40	5.85
Saving	-24.71	-1.08	-25.94
Expenditure	4.32	-1.08	5.76
Household income	-1.32	-1.08	-1.37
Labour income	-0.75	-1.31	-0.13
Capital income	-3.77	-	-3.77
Disposable income	-1.87	-1.08	-2.12
Welfare	4.32	-1.40	5.85

Source: simulation results

Table 6. 18 Household Consumption Effects across Sectors and Sales Tax Compensation SIM -2

Variable	Base	Shock	%
AGRI	38126	39558.43	3.76
CRDO	1089	940.24	-13.66
REFI	6582	6675.03	1.41
MANF	118859	129360.60	8.84
UTIL	4778	4755.64	-0.47
CONST	378	388.16	2.69
TRDS	146616	148868.40	1.54
NTRDS	14685	15046.78	2.46
total	331113	345593.30	4.37

Source: simulation results

progress amount of 5.85%, while non-Saudi household worse off by -1.40% due to the decline in expenditure and consumption (-1.08% and -1.40 respectively).

vi. Note about the simulation results:

As we mentioned earlier private consumption may increase if income increases and consumer price decreases. But the result shows the opposite. Income declines due to the demand for labour decline across sectors which result in decline wage and eventually contract household income. One may observe that the drop in import prices is larger than the increase in domestic price, -3.96% and 2.96% , respectively. Thus, one would expect that this relative price change favoring imports would lead to a reduction in domestic production (-0.49%) and eventually composite good (QQ) registers an increase of 1.4%.

There is a similar case in Philipen, Cororaton (2003) justifies the result as follows:

"If one puts these results in the framework of production theory where imports and domestic production are factor inputs and one isoquant indicates one level of output, the results would indicate an outward shift in the isoquant since QQ is higher together with higher imports production". It seems that the increase in domestic prices favour the decline in import price result in increase composite commodities and eventually increase consumption.

With respect to the decline in GDP as a result of dropping tariff accompanied by sale tax, the case of Kenya as we mentioned earlier is a good example in which trade liberalization measure was accompanied by an increase in indirect taxes, real GDP increase is much smaller (half a percentage point). Effect on output of this policy would have been worse compared to the sole trade liberalization. The increased costs through higher indirect taxes caused larger reduction in production.

6.2.5 Third Simulation (SIM -3)

This simulation is similar to SIM-2 except indirect tax is replaced with direct tax[28] to fund the revenue loss due to tariff abolition.

i. Macroeconomic Effects of Tariff Abolition

Table 6.21 and Figure 6.5 show macroeconomic effects as a result of the removal of tariff and the imposition of a direct tax. GDP registers significant increase at factor cost (12.63%) but experiences a marginal decline (-0.38%) at market price. Tariff elimination affect relative prices and result in a decline in overall domestic import prices (by 3.93%) which in turn increases total import by 14.61%.Aggregate private consumption shows an increase of 7.78% as does government expenditure (5.76%) due to a decline in the composite price (-10.76), but total investment experiences decline by -8.13%.

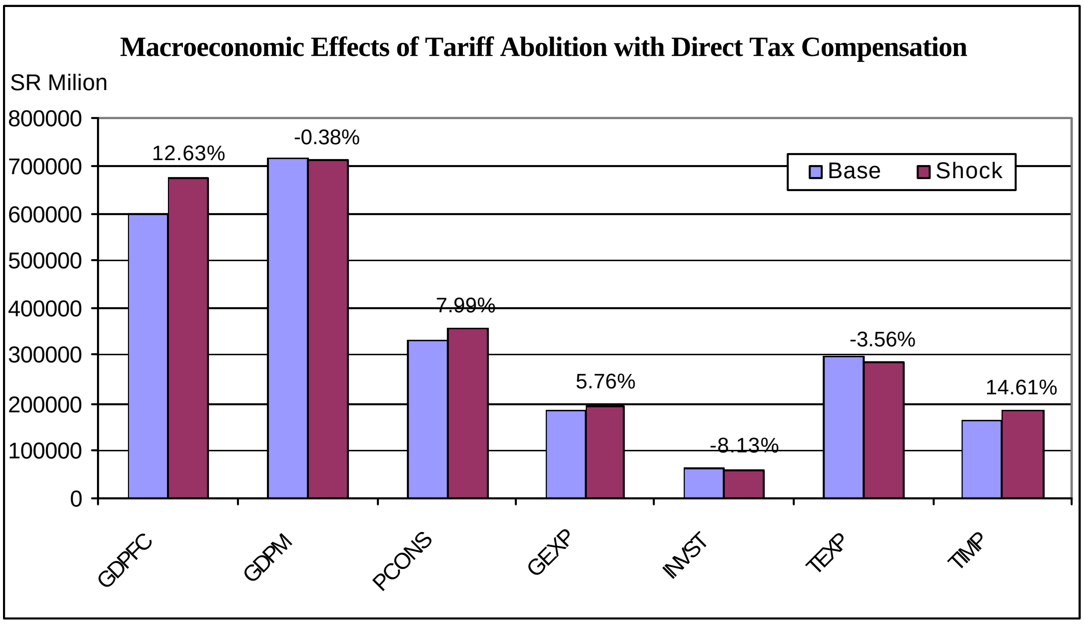
[28] There is no income tax levied on people in Saudi Arabia, the adjusted direct tax rate is 0.104.

Table 6.19 Macroeconomic Effects of Tariff Abolition and Direct Tax Compensation, (SIM-3)

Variable	Base	Shock	%
GDPFC	599287	674947.6	12.63
GDPM	714552	711868.9	-0.38
PCONS	331113	357540.9	7.98
GEXP	183805	194397.6	5.76
INVST	62730	57633.16	-8.13
EXP	297539	286393	-3.75
IMP	160635	184095.8	14.61

Source: Simulation results.

Figure 6.5 Macroeconomic effects of Tariff Abolition and Direct Tax Compensation, (SIM-3)



ii. Effect on Prices and Volumes of Commodities

The price and volume effects are presented in Table 6.22. Tariff elimination results in an overall reduction in the domestic price of imports (PM) by -3.93%. Similarly, the overall composite price (PQ) significantly declines by -10.76% while domestic price of local goods (PD) declines by -10.14%. Thus tariff reduction companied by a direct tax translates into reduced domestic prices. However, the reduction in domestic price is larger than the import price, this is reflected in a slight decline (-0.06%) in the sectoral price ratio between domestic prices and the corresponding import price (PD/PM). So the decline in price of imported goods results in substitution between imports and domestically produced goods to increase in favour of volume of imported goods (14.71 %.) Since the decline in domestic price, domestic production for domestic sales (QD) increases by 2.20% but still is insufficient to meet the domestic demand which increases imports as mentioned earlier. Taken together these changes result in an increase in the total goods available in the market (QQ) by a 4.37%.

However, the price ratio between domestic and export price (PD/EP) indicate a slight contraction (-0.11%) translated to a decline in total volume exports (-5.70%). The effects at the sectoral level vary considerably across sectors. Agriculture, refinery and manufacture experience a decline in import prices (-7.90%, -7.80%, -7.90% respectively.)

The decline in import prices results in progress in imported quantities. It is observed differently across sectors, the largest increase (33%) appears in agriculture followed by refinery (25.68%), manufacturing (15.52%), trade (10.77%) and utility

Table 6. 20 Price and Volume Effects of Tariff Abolition and Imposition Direct Tax, (SIM-3)

	Price Change %							Volume Change (%)				
	PM	PE	PD	PQ	PX	PD/PM	PD/PE	QM	QE	QD	QQ	QX
AGRI	-7.90	0.00	5.10	3.40	5.1	0.14	0.051	32.99	-7.64	-0.46	3.24	-0.50
CRDO	NON	2.70	-93.70	-93.70	-20.20	NON	-0.939	NON	-8.08	38.67	38.67	-0.07
REFI	-7.80	0.00	-1.00	-1.10	-0.40	0.07	-0.010	25.68	4.45	2.92	3.15	3.87
MANF	-7.90	0.00	-2.80	-5.20	-2.30	0.06	-0.028	15.52	3.60	-0.65	6.61	0.00
UTIL	0		-2.30	-2.30	-2.30	-0.02	0.000	1.6	-0.37	6.12	6.12	6.12
CONST	0	0.00	0.20	0.20	0.20	0.00	0.002	0.35	NON	-0.05	-0.04	-0.05
TRDS	0	0.00	5.80	5.00	5.60	0.06	0.058	10.77	-8.42	-0.40	0.89	-0.55
NTRDS	NON	NON	7.60	7.60	7.60	NON	0.000	NON	NON	0.09	0.09	0.09
Total	-3.93	0.45	-10.14	-10.76	-0.84	-0.06	-0.11	14.71	-5.70	2.20	4.37	0.03

Source: Simulation results.

PD/PM= [(PD1/PM1-PD0/PM0)/PD0/PM0]*100
PD/PE= [(PD1/PE1-PD0/PE0)/PD0/PE0]*100

(1.60%) while the construction sector only registers an increase of 0.35%. Export volume on the other hand rises in the refinery and manufacturing sectors by 4.45% and 3.60% respectively, but the other sectors suffer a contraction; the decline is due to the increase in price ratio (PD/PE)[29] for these commodities. The results on manufacturing need further explanation since this sector is a major contributor to the total import as I mentioned earlier. In particular, results on the sector's imports (QM), domestic production (QD) and the composite goods (QQ). One may observe that the drop in its import prices is larger than in its domestic prices, (-7.90% and -2.80%, respectively).

Thus, one would expect that this relative price change favouring imports would lead to a reduction in domestic production. The result on domestic production indicates a decrease of -0.65%, the composite good (QQ) for the sector registers an increase of 6.61%.

iii. Factor Market Effects

The results of factor market effects are presented in Table 6.23. The study assumes that sectoral capital and non-Saudi labour are fixed. Therefore, any change in production can only come from a reallocation of labour among sectors. Unlike capital, labour is free to move from one sector to another in particular Saudi labour (since non-Saudi labour is assumed fixing by sector) as tariffs are eliminated. The simulation results show an increase in the average rental rate of capital (25.60%). Overall wages rise by 18.75%, across labour, on the other hand, they improve for Saudi and non-Saudi labour (10.41% and 25.35% respectively).

Across sectors however, the results vary. For example, in the sectoral return to

[29] See equation (17) chapter 5.

Table 6. 21 Factor Market Effects of Tariff Abolition and Imposition Direct Tax, (SIM-3)

Variable	Factor Intensity (K/L)		% Change in return to capital	% Change in Labour Demand		
	Base	Experiment		Aggregate Labour	Saudi Labour	Non-Saudi Labour
AGRI	0.132	0.135	5.7	-2.39	-4.28	0
CRDO	0.553	0.560	8.3	-1.20	-1.87	0
REFI	0.156	0.120	118.8	30.54	98.17	0
MANF	0.096	0.096	10.4	-0.01	-0.02	0
UTIL	0.031	0.028	33.2	12.67	20.62	0
CONST	0.046	0.046	9.5	-0.13	-0.86	0
TRDS	0.042	0.042	8.2	-1.22	-2.03	0
NTRDS	0.006	0.006	10.7	0.11	0.27	0
Total	0.000	0.000	25.60	0.00	0.00	0
Average Wage				18.75	10.41	25.35

Source: Simulation results.

capital all sectors experience an increase, the highest increase is in refinery sector (10.40%) the lowest increase registered is in the agriculture sector (5.70%). As a result, these changes trigger substitution between capital and labour. There is a (118.8%) followed by utility (33.20%), non-trade (10.70), and manufacturing tendency for the demand for labour to increase in three sectors: refinery (30.54%), utility (12.67%), and non-trade (.11%), whereas the demand for labour in the rest of the sectors declines. In sum, the results of the experiment indicate that the refinery, utility and non- trade sectors benefit most from effects of output reallocation and labour movement.

iv. Household Income and Consumption Effects

The results on the average wage rate and rental rate are relevant in assessing the effects on household income. The effects indicate that in all sectors wages and return to capital result in progress for household income.

Table 6.24 reports that overall labour income increases by 11.35%. Across labour, Saudi and non-Saudi labour enjoy increase of 10.41% and 12.20% respectively. In fact, all households, both Saudi and non-Saudi, enjoy a positive increase in labour income. On the other hand, Saudi household capital income registers an increase of 16.52%. The increase in factor income led to increase in total income of households by 7.91%. The increase appears across households, Saudi and non-Saudi households (10.07% and 7.48% respectively.)

In discussing the effects on disposable income we are reminded that as we mentioned earlier the closure rule used in this particular experiment is investment-driven for Saudi households and vice-versa for non-Saudi households and by definition: Disposable income = Gross income – direct tax. So, dropping tariffs accompanied by direct tax in this scenario directly affects disposable income in which total disposable income declines marginally by -0.48% across households, Saudi household decrease by 0.20% and non-Saudi households decrease by-1.38%. On the level of household consumption, there are two major factors influencing household consumptions as mentioned earlier: domestic prices and household income. Domestic prices decline and household income grows. Hence, overall household consumption increases by 7.98%. Across households, Saudi households show a significant increase of 10.67% while non-Saudi households experience a decline by -2.06%. With respect to consumption across sectors, Table 6.25 shows different sectors with different level of consumption. The highest increase in consumption comes from crude oil which accounts for 1611.30%[30], followed by the manufacturing sector (14.22%), utility (11.50%) and construction sectors (8.09%)

[30] The large decline in crude oil composite price (-93.70%) result in large consumption.

while the non-trade sector only increases by 0.69%.

v. Households Welfare Effects

Table 6.24 reports the welfare effects of tariff abolition accompanied by implementing direct tax. There are contributions to welfare from changes in relative prices, as producers and consumers adjust their purchasing and sales patterns in response to a policy change, in addition there is progress in the household income as mentioned earlier. As a result overall households experience an improvement in welfare, EV increases by 7.98%. Across households, Saudi household gain (10.67%) while non-Saudi household lose out (-2.06%) due to the decline in expenditure and consumption.

Table 6.22 Household Income and Consumption Effects of Tariff Abolition and Imposition Direct Tax, (SIM-3)

% Change in:	Total	Non-Saudi	Saudi
Consumption	7.98	-2.06	10.67
Expenditure	7.98	-1.38	10.49
Total income	7.91	10.07	7.48
Labour income	11.35	12.21	10.41
Capital income	16.52	0.00	16.52
Disposable income	-0.48	-1.38	-0.20
Welfare	7.98	-2.06	10.67

Source: Simulation results.

Table 6.23 Household Consumption across Sectors Effects of Tariff Abolition and Imposition Direct Tax, (SIM-3)

Variable	Base	Shock	%
AGRI	38126	39944.13	4.77
CRDO	1089	18636.03	1611.30
REFI	6582	7205.23	9.47
MANF	118859	135763.24	14.22
UTIL	4778	5327.18	11.49
CONST	378	408.60	8.09
TRDS	146616	150108.30	2.38
NTRDS	14685	14785.57	0.69
Total	331113	372178.28	12.40

Source: Simulation results.

vi. Note on the simulation result of SIM-3

In the second experiment, third simulation (SIM3), trade liberalization accompanied by direct cause a decline in real GDP. This is consistent with a result from Kenya in witch Karingi and SieiX (2001) consider effect of trade liberalization on Keynian econom. The result indicates that real GDP experiences a decline of 0.4% as a result of trade liberalization accompanied by increase in direct tax.

With respect a decline in investment in the same simulation, commodities produced in different sectors are used for investment purposes and for satisfying government and household consumption demands. Habeeb (1991) in his above study mentions that although the saving of oil and non-oil sectors increased, total savings decreases. This was a consequence of a decline in foreign saving. As a result, total investment decreased. In a sense, the level of available savings determines total investment. Non-oil exports decline while nominal GDP increase. Despite the decline in investment all nominal wages increase which turn in household income to increase. It is appear a similarity between Habeeb's results and our finding in this experiment.

6.3 Sensitivity Analysis

6.3.1 Sensitivity Analysis in case full employment

Finally, it is common for most studies to carry out an examination of the sensitivity analysis of the results to key assumptions. In the preceding discussion, many assumptions were made with regard to model structure and parameter estimates (chapter 5). A full examination and discussion of these assumptions would be virtually impossible. Consequently, only results from the sensitivity analysis of Constant Elasticity of Substitution (CES) are examined. The sensitivity analysis will be carried out on the second experiment, first simulation (SIM-1). I first doubled and then reduced by half the initial value of CES. This was intended to analyse how sensitive the results were to these large changes.

Doubling the parameter estimate, by improving flexibility of the estimates, generally reduces adverse effects of any policy change by raising welfare, reducing unemployment rate and increasing national output (Nyamadzabo, 2003). Table 6.26 and Figure 6.6 give the results of parameter changes.

In this study doubling CES values results in progress in GDP at factor cost (12.77%) and GDP at market price shows a minor increase (0.07%). Private and goverment consumption register expansion of 11.70% and 6.79% respectively. However, investment shows a contraction of -8.11%, exports decline by -3.34%. Imports, on the other hand report a significant increase of 22.21% and finally welfare measured by equivalent variation (EV) is better off (11.69%).

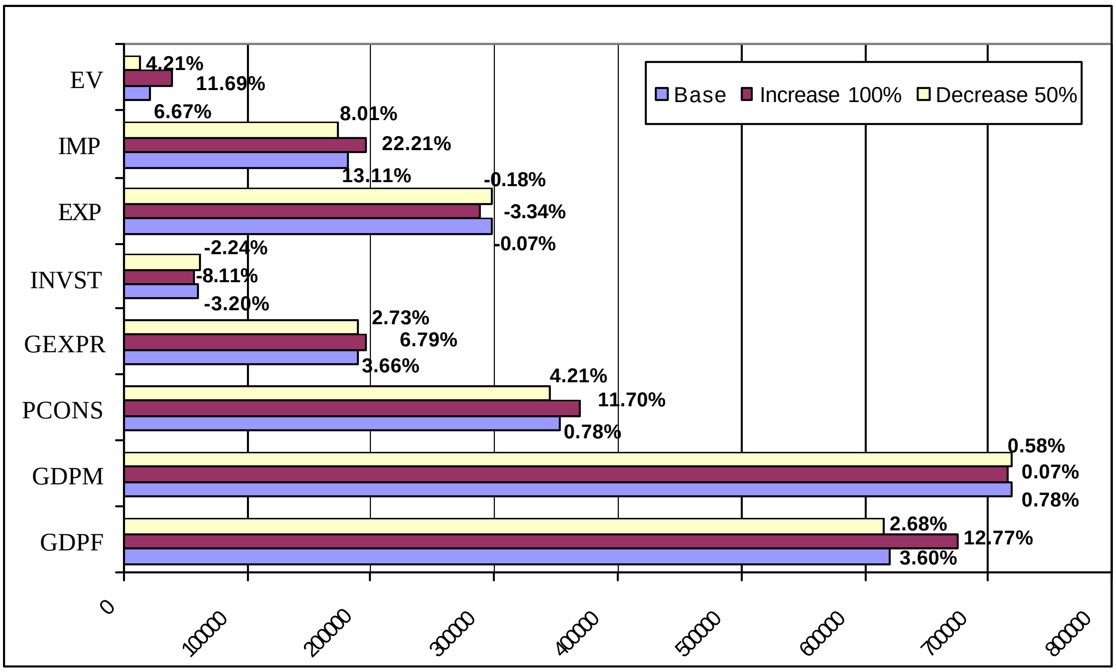
Halving parameter estimates to reduce the sensitivity (or flexibility) of the estimate tends to have adverse effects on welfare by increasing negative values for equivalent variation (EV), increases unemployment rates and reduces national

Table 6. 24 Household Consumption across Sectors Effects of Tariff Abolition and Imposition Direct Tax, (SIM-3)

Variable	No change in CES		100% increase CES		50% decrease CES	
	Value	% Change	Value	% Change	Value	% Change
GDPFC	620877	3.60	615372	12.77	615372	2.68
GDPM	720095	0.78	718674	0.07	718674	0.58
PCONS	353208	6.67	345039	11.70	345039	4.21
GEXP	190535	3.66	188826	6.79	188826	2.73
INVST	60722	-3.20	61322	-8.11	61322	-2.24
EXP	297321	-0.07	296992	-3.34	296992	-0.18
IMP	181691	13.11	173505	22.21	173505	8.01
EV	22095	6.67	13926	11.69	13926	4.21

Source: Simulation results

Figure 6.6 Sensitivity Analysis: Doubling and Halving Parameter (CES) Values with Elimination Tariff (SIM-1)



Source: Simulation results

output (GDP). GDP at factor price shows less increase compare to doubling elasticity (2.68%) while GDP at market price reports much less increase (0.58%)

relative to the base. Private and public consumption show an increase, but less than the base or doubling estimates (4.21% and 2.73% respectively). However, halving CES affects investment but is less negative (-2.24). The same effect is observed for exports but less than the base and doubling estimate (-0.18%.) Import and welfare, on the other hand, register an improvement but less than the base and doubling estimate (8.01% and 4.21% respectively).

Apparently, the model shows sensitivity to a change in parameter values either an increase or decrease in estimate value.

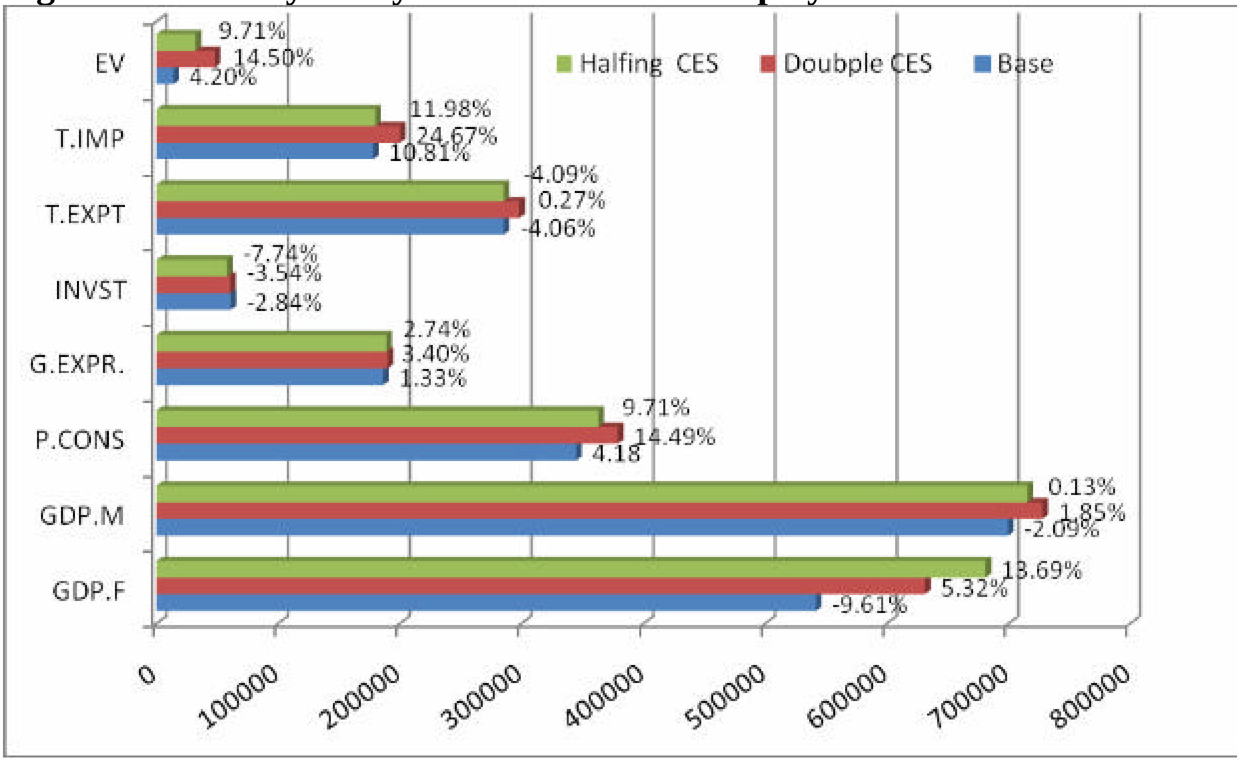
It is realized a remarkable change within variables' values after change CES. On one hand the large effect of CES values essentially comes from the elasticity estimates which basically are calculated from different country differs from Saudi economy, on the other hand the model we build is a monopolist model, it is sensitive to these estimates. So, it is better for future work to choose elasticity estimates that originally calculated based on Saudi economy.

6.3.2 Sensitivity Analysis in Case Unemployment

Given the assumption of full employment of labor, the wage rate for labor adjust until the sum of sectoral demand for labor equals the fixed supply of the labor. The alternative assumption is less employment of labor, in this case the wage is kept fixed and leave unemployment adjust to clear the market. The latter will be applied to see the changes in the sensitivity analysis.

Figure 6.7 shows the sensitivity analysis in case less employment by modified the closure rule. When there is no change in estimate values of CES, the results indicate that GDP at factor price declines by -9.61% from the base line but

Figure 6.7: Senility Analysis in Case less an Employment



Source: Simulation results

the situation progress when we increase CES by double and decrease CES by half (5.32% and 13.69% respectively). Private and public consumption increase by 4.19% and 1.33% respectively in base and improve more when double estimates (14.49% and 3.40% respectively) and when decrease by half (9.71% and 2.74%), which turn in increase in household welfare in base, double and half (4.19%, 14.49% and 9.71% respectively). It seems that the improvement in consumption and eventually welfare (despite the decline in GDP at factor price) comes from the availability of imported goods due to lower prices. The figure shows that imports increase by 10.81% in base, improved more when increase (double) and decrease (half) CES by 24.7% and 11.98% respectively. In contrast, exports experience decline in base and decrease (half) CES by -4.06% and -4.09% respectively but marginally increase when double CES (0.27%).

Comparing this case when we adopt unemployment assumption with no unemployment, it is clear the direct effect on GDP at factor price when it decline in the former and increase in the latter. With respect to welfare effect, household is better off in both assumptions since consumption increase in both scenarios due to decline of import price. Investment experience contraction in both cases as a result of savings decline.

From the two sensitive analysis, it is realized a remarkable change within variables' values as a result of change CES. On one hand the large effect of CES values essentially comes from the elasticity estimates which basically were calculated from different country differs from Saudi economy, on the other hand the model we build is a monopolist model, it is sensitive to these estimates. So, it is better for future work to choose elasticity estimates that originally calculated based on Saudi economy.

6.4 Conclusion

In this chapter, two experiments were performed in order to analyse the impact of the external shock of oil demand and the liberalisation regime on the Saudi economy. The first experiment assumes there is an external shock namely increasing oil demand by 5%. The second experiment examines the effects of a liberalisation regime (tariffs abolition) on the Saudi economy.

The simulation results with respect to the first experiment show that economic performance is better when demand for oil increases by 5% and results in a windfall oil price, expanding oil exports improve government revenue. The closure rule on the other hand plays a crucial role in the results. Welfare effects are better in the case of saving-driven investments, in which savings are fixed and investment is flexible to clear the market. The household worsen in the case of investment-driven savings where investment is fixed and savings are flexible.

For the second experiment, there are three simulations. Firstly, eliminate tariffs completely without compensating for the reduction in government revenue as a result of tariff abolition. Secondly, eliminate tariffs and impose a sales tax in order to compensate the decline in government revenue. Thirdly, the compensation in this simulation is made through a direct tax.

Household welfare change was checked. In terms of the first experiment with two simulations, household welfare experiences a decline. The decline in the second simulation is more than the first simulation due to the closure rule change.

For the second experiment, welfare effect varies amongst the three simulations. In SIM-1, households are better off in both groups (Saudi and non-Saudi households). In SIM-2, overall households are better off but across households, Saudi households gain but non-Saudi lose out. In SIM-3, overall households experience improvements in welfare but across households, Saudi household gain while non-Saudi household suffer losses due to the decline in expenditure.

The sensitivity analysis carried out to examine the robustness of the model to the changes in parameter values (e.g.CES) shows that the model is highly sensitive to change in elasticities values.

Chapter 7
Conclusions and suggestions for future research

7.1 Conclusions

In response to the research questions formulated, this study provides a consistent framework that can assist Saudi Arabian policy makers in evaluating a wide range of policy change and exogenous shock measures by providing an empirical general equilibrium assessment of several policy scenarios. It also offers an analysis of the structural relationships among different economic agents to improve the understanding of the Saudi economy. It provides a historical perspective on Saudi economic evolution and reviews the significant progress achieved since 1970, focusing on a review of economic performance and the national development plans.

The standard structure of the CGE model follows Lofgren et al. (2002). It explains all the payments recorded in the SAM. CGE applications to oil exogenous shocks and fiscal policy were explained and supported with some examples from the literature. One of the identifiable sources of shocks that have attracted the attention of many economies is oil demand and oil price shocks. The effects of these shocks on the economies have been widely recognised in the literature. On the other hand CGE models are also widely applied to trade liberalisation and several examples of this were provided.

The structure of the Saudi Social Accounting Matrix (SAM) for 2000 has been described. The SAM has served two purposes. Firstly, it has enabled an analysis of the structural relationships among the various economic agents in a consistent framework. Secondly, it has been used as the database for Saudi CGE model. The Saudi SAM has been explained along with the presentation of each of the 8 main accounts: commodity accounts, production sector accounts, factors of production accounts, household sector account, government sector account, tax accounts, savings/investment accounts and the external sector account. The production sectors accounts showed that labour is mobile across sectors while capital is sector-specific (immobile). This assumption affects the cost of this factor compared to the capital factor because of the decline in labour wages.

The model is a static multi-sector CGE model, run for one period (2000), which closely follows the approach of Lofgren, Harris and Robinson (2002) with some changes to better fit the Saudi economy. The model explains all payments based on the Saudi SAM (2000). Justification for adopting the Lofgren et al. (2002) CGE model is discussed in Chapter 5.

In this model producers maximise profits, while consumers maximise utility. Equilibrium is characterised by a set of prices and levels of production factors are fully utilised, prices are set so that equilibrium profits are zero. Oil sector profit mark-up is applied since the producer (government) act as monopolist and sets the price above unit cost. Factor incomes are divided among households (total household income is used to save and consume), while government revenue come from indirect taxes, tariffs and oil profit. Household incomes equal household expenditures (equilibrium condition). Household goods consumption is determined by assumptions about consumer behaviour. The Armington (1969) approach allows us to treat domestically-produced and imported varieties of a good as imperfect substitutes, so that changes in relative prices lead to some (but not complete) substitution between domestic and imported goods, according to a constant elasticity of substitution (CES) function. Similarly, on the export side according to a constant elasticity of transformation (CET) function, it may be assumed that there is an imperfect transformation in production between varieties produced for the domestic market and those for foreign markets, which allows divergence between the domestic price of exportable goods and their world prices.

On the other hand, the accession to the WTO is among the most important policy changes that a country may undertake. Saudi Arabia became a member of World Trade Organisation (WTO) in 2005. The benefits and challenges that the country may faces as a result of accession to the WTO calls for urgent economic reforms in order to mitigate the impact of trade reforms implemented by the WTO on the Saudi economy.

- **Summary of Results**

It is apparently the importance of examining the effects of the oil demand shock and trade reform policy on the Saudi economy. I carried out the first experiment in which the world oil demand shocked by 5% increase. Table 7.1 shows the results of this experiment. The increase in oil demand by 5%, results in an increasing in oil price by 7.21% which in turn increase total exports 5.50% (oil export make up about 90% of total export value) and ultimately oil profit increase by 37.50% which expand the government revenue by 9.27%. GDP on the other hand also experience progress increases by 5.52%, as well as total imports increase by 2.54%. However, government expenditure marginally decline by -0.20% and private consumption decline by -1.46% which reflected in welfare loss by -1.46% from the base line.

These findings are consistent with the real situation when world oil demand has increased through 2000-05 as is illustrated in Table 7.2. The study gives an indication to the policy makers to bear in mind these results when they set up the

Table 7. 1 First Experiment: Increase Oil Demand by 5% (GDP in real term)

Variable	% change
Oil Price	7.21
PROFC	37.50
GR	9.27
GDP	5.52
PCONS	-1.46
GEXP	-0.20
EXPORT	5.50
IMPORT	2.54
WELFARE	-1.46

Source: Experiment results

PROFC: Oil profit; GR: Government revenue; GDP: Gross Domestic Product
PCONS: Private consumption; GEXP: Government expenditure

Table 7. 2 Relationship of World oil Demand, Oil Prices and Saudi GDP (constant price 1999)

Year	World Oil Demand Million, barrel/day	% change	Oil price	Saudi GDP, SR, million
2000	78.387	--	26.81	623237
2001	79.157	0.98	23.06	629265
2002	79.872	0.90	24.32	629772
2003	81.524	2.07	27.69	678183
2004	84.360	3.48	34.53	713899
2005	86.021	1.97	50.15	757208

Source: chapter 2, Table 2.1 and 2.2.

state development plans. The government will expand the current projects and create new ones in case the positive shock of oil demand which result in a large budgetary.

Trade liberalization, particularly tariff reduction affects domestic foreign price ratios which triggers changes in sectoral prices. These changes in turn result in reallocation of production and resources, which could lead to contraction in some production sectors and expansion others. The second experiment was performed to examine the effect of elimination of tariff on the economy. Three simulations were applied. 1) Abolition tariff without compensation the reduction in government revenue as a result of dropping tariff. 2) Dropping tariff accompanied by sales tax.
3) Eliminating tariff companied by income tax. Table 7.3 reports the results of this experiment.

The first simulation eliminates tariff tax without compensation the reduction in government revenue. This policy would result in a decline in the government revenue. The effects of trade liberalization on national income aggregates reveal that tariff abolition reduces the price of imported commodities relative to domestic goods, thereby causing a shift of the demand curve towards imported goods and away from domestic production. Total import demand significantly increase by 13.24%., total export marginally decline by -0.07%, private and government consumption increase 6.67% and 3.66% respectively. This progress reflected in increase the GDP by 3.60% which in turn improve the welfare (6.67%).

The second simulation, dropping tariff is accompanied by sales tax. The result reveals that despite the improvement in economy but it seems less than the first simulation. Total import significantly increase by 8.92% due to the decline of

Table 7. 3 Second Experiment: Tariff Elimination Results

Variable	Tariff liberalization Scenarios		
	Drop tariff only (%)	Drop tariff and add sales tax (%)	Drop tariff and add direct tax (%)
GDP	3.60	0.15	12.63
PCONS	6.67	4.32	7.78
GEXP	3.66	2.33	5.76
EXPORT	-0.07	0.15	-3.75
IMPORT	13.24	8.92	14.61
WELFARE	6.67	4.32	7.98

Source: Experiment results

import price , exports marginally increase by 0.15%, private and public consumption increase 4.32% and 3.33% respectively, due to the import price decline. GDP marginally increases by 0.15% and finally household welfare better off (4.3250).

Finally, third simulation, the tariff drop is companied by direct tax. The findings show decline overall domestic import price (-3.93%), in turn increases the total imports by 14.61%, total exports experience decline by -3.75%. Aggregate private consumption shows an increase as well as government expenditure account for 7.78% and 5.75% respectively due to decline the composite price. The GDP as a result improved (12.63%) and household welfare gain (7.98%).

Because of a significant increase in GDP and welfare, it is appropriate for the government to adopt SIM-3 in case she is forced to compensate the revenue reduction due to dropping tariff**.** However**,** since the tariff revenue represents a small portion of the government revenue (1.9%) as I mentioned earlier, it is better for the government to avoid imposing tax (sales or income tax), due to the fact that imposing tax will add burden on people. The government can compensate the reduction from oil revenue in addition the tariff elimination incentive the economy activities which in turn improve GDP and welfare as it is illustrated in the second experiment first simulation (SIM-1).

7.2 Some limitations and suggestions for future research

As with any economic analysis, the study has shortcomings that could be improved in future research. Such improvements include better model specifications and better data for the benchmark equilibrium.

7.2.1 The Saudi CGE model (in this study) focuses on the real side of the economy. In other words, the model dealt with the real side of the economy where only relative prices matter. Thus one may take these formulation for a more specialised study of financial markets in the Saudi economy. It will demonstrate how the financial sector affects various agents (the government, central and commercial banks, households, production firms, and rest of the world). Looney (1990) points out:

> *As the country was experiencing the stimulation effect associated with increased oil revenues during the 1970s and early 1980s, there was little to worry about adequate liquidity for funding various private sector activities, including investment in plants and equipment. With reduced oil revenues, however, there is increased concern in Saudi Arabia that the Saudi Arabia Monetary Agency (SAMA) will not be able to assure adequate liquidity for financing a steady expansion in private sector activity.* P111

7.2.2 The present study utilises household data as found in the Saudi SAM. The household classification in the Saudi SAM is not based on income but on nationality (Saudi and non-Saudi households). For a future study one could develop a sample version using household data based on income (i.e. Ballard 1987). A SAM could be created with data using different household classifications possibly based on the availability of outstanding source data. Moreover, the desegregation of households in different income groups could allow an evaluation of the distributional effects of the fiscal policy measures. Unfortunately, the limited availability of data made such an analysis impossible. This issue could be addressed in the future depending on the data availability.

7.2.3 The CGE model only considered two labour markets based on nationality as well. The model could incorporate different labour markets with different categories (e.g. skills) or any household categories and that might enrich the analysis of the labour markets in Saudi Arabia.

7.2.4 The results of this study were based on a static model. A specification of a dynamic CGE model would be appropriate because it can accommodate the time frame that allows households and industries to adjust to changes in their activities in each period. A dynamic model could capture household saving behaviour since household utility depends on both present and future consumption, and investment at each period of time could be better reflected in a dynamic setting. As mentioned by Ballard (1987) a tax analysis using a static general equilibrium model could give some misleading results if used for a long term analysis. Using a static CGE model, a policy that looks harmful in the short term can provide substantial welfare gains in the long term. Therefore, in order to capture the long term effects of a tax policy. it is important to adopt a dynamic CGE model.

7.2.5 The present study uses the SAM data of 2000. A possible modification would be to update the present statistics with the latest SAM data that will be more accurate and reflect the current situation in the country and eventually improve the results.

7.2.6 The model results were very sensitive to the estimates of various elasticities (CES and CET) used in the study. The study relied mostly on other country's elasticity. There is no research done at national level to estimate elasticities for Saudi Arabia. The model results could be improved by using national data in order to quantify the elasticities.

Appendixes

Appendix 1

Calibration Parameters

Shift coefficients in the activity production function.

$ad_a = QA_c / \prod QF_{fa}^{\alpha_{fa}}$

Elasticity coefficients in the activity production function. using the FOC, for Saudi labor

α : alpha('SLAB',A) = SAM('SLAB',A)/FCSTA0(A);

Elasticity coefficients in the activity production function. using the FOC, for non-Saudi labor

α :alpha('NSLAB',A) = SAM('NSLAB',A)/FCSTA0(A);

Elasticity coefficients in the activity production function. using the FOC, for capital

α :alpha('CAP',ANO) = SAM('CAP',ANO)/FCSTA0(ANO);

α :alpha('CAP',AO) = (SAM('CAP',AO) - PROFA0(AO))/FCSTA0(AO);

Shift coefficients in the activity production function.

ad : ad(A) = QA0(A) / PROD(F, QF0(F,A)**alpha(F,A));

$ad(A) = QA_c / \prod QF_a^{\alpha}$

The implied exponent coefficients in the CES functions:

ρ_q: rhoq(C) = 1/sigmaq(C)-1;

ρ_x: rhox(C) = 1/sigmax(C)+1;

Share coefficient in the CES transformation equation

δ_x: deltax(C)$CE(C)=1/(1+ ((PD0(C)/PE0(C)) * ((QE0(C)/QD0(C))**(rhox(C)-1))));

$\delta_x = 1/\left((1 + PD_c / PE_c)(QE_c / QD_c)^{\rho_c - 1}\right)$

Share coefficient in the CES aggregation equation

δ_q :deltaq(C)$CM(C)=1/(1+((PD0(C)/PM0(C))* ((QD0(C)/QM0(C))**(rhoq(C)+1))));

$\delta_q = 1/\left((1 + \left((PD_c / PM_c\right)(QD_c / QM_c)^{\rho_{c+1}}\right)$

Shift coefficient in the CES transformation equation

ax : ax(C)$CE(C) = QX0(C)/(deltax(C)*QE0(C)**(rhox(C))
+ (1-deltax(C))*QD0(C)**(rhox(C)))**(1/rhox(C));

$ax_c = QX_c / d_c QE_c^{rx_c} + (1 - dX_c QD_c^{rx_c})^{1/rx_c}$

Shift coefficient in the CES aggregation equation

aq : aq(C)$CM(C) = QQ0(C)/(deltaq(C)*QM0(C)**(-rhoq(C))
+ (1-deltaq(C))*QD0(C)**(-rhoq(C)))**(-1/rhoq(C));

$aq_c = QQ_c / \left(dq_c QM_c^{-rq_c} (1 - d_c QD_c^{-r_c} \right)^{-1/rq_c}$
Consumption shares
b : beta(C,H) = PQ0(C)*QH0(C,H)/EH0(H);
$b_{c,h} = PQ_c QH_{c,h} / EH_h$
Household income share from factor incomes
$shry$: shry(H,F) = SAM(H,F)/SAM('TOTAL', F);

Marginal propensity to save
MPS : MPS0(H) = SH0(H)/(DIH0(H)-TR0('ROW',H));

Appendix 2

Derivation

i. **Derivation of Equation (32) and (33).**

To derive (32), we differentiate both sides of (29) w.r.t. PE_c

$$\frac{\partial QE_c}{\partial PE_c} = \frac{\partial ROWOD}{\partial PE_c} - \frac{\partial ROWOS}{\partial PE_c}$$

and converting the derivatives to elasticities,

$$\frac{PE_C}{QE_C} \cdot \frac{\partial QE_c}{\partial PE_c} = \frac{ROWOD}{QE_c} \cdot \frac{PE_c}{ROWOD} \cdot \frac{\partial ROWOD}{\partial PE_c} - \frac{ROWOS}{QE_c} \cdot \frac{PE_c}{ROWOS} \cdot \frac{\partial ROWOS}{\partial PE_c}$$

and using the definition $e_{rowod} = -\frac{PE_c}{QE_c} \cdot \frac{\partial QE_c}{\partial PE_c}$ and from (30, 31, 33, 34) we have

$e_{rowod} = -\frac{PE_c}{ROWOD} \cdot \frac{\partial ROWOD}{\partial PE_c}$, and $e_{rowos} = \frac{PE_c}{ROWOS} \cdot \frac{\partial ROWOS}{\partial PE_c}$

which can be substituted in the above to give (32):

$$PE_c = \frac{AVCST_c}{(1 - 1/e)}; \; c \in CO$$

Equation (33) is the standard monopolist pricing rule. In general, the condition for profit maximization is Marginal Revenue= Marginal Cost. Given that revenue is PQ and P is determined on a downward sloping demand $P(Q)$, it follows that

Marginal Revenue= $\frac{d(p(Q) \cdot Q)}{dQ} = p + Q\frac{dp}{dQ} = p\left(1 + \frac{Q}{p}\frac{dp}{dQ}\right)$

The pricing rule is obtained by Marginal Cost = Average Cost and noting that $\frac{Q}{p}\frac{dp}{dQ} = -\frac{1}{e}$ is the inverse of price elasticity of demand. Hence, it follows that $p\left(1 - \frac{1}{e}\right) = Average\ Cost$, which is the required result.

ii. Derivation of Equation (54)and (55) [EV and CV].

Substituting $QH_{c,h} = b_{c,h} EH_h / PQ_c$ in $UTILH_h = \prod_{c \in C} \left(QH_{c,h} / b_{c,h} \right)^{b_{c,h}}$ we obtain the indirect utility

$$VH_h = \frac{EH_h}{CPIH_h} \text{ or } EH_h = CPIH_h \cdot VH_h \qquad (1)$$

$UTILH_h = VH_h$ by definition.

Let V, E and CPI denote aggregate indirect utility, consumers' expenditure and consumer price index for the economy, respectively.

Given that $E = \sum_h EH_h$, (2)

And assuming that V, E and CPI satisfy

$E = CPI \cdot V$

we can use 1 and 2 to write

$$CPI \cdot V = \sum_h CPIH_h \cdot VH_h \qquad (3)$$

Thus, we can define CPI as

$$CPI = \sum_{h \in H} m_h CPIH_h \qquad (4)$$

where $m_h = \frac{VH_h}{V}$ and $V = \sum_h VH_h$. Hence, given that $UTILH_h = VH_h$, define

$$m_h = \frac{UTILH_h}{\sum_{h \in H} UTILH_h} \qquad (5)$$

Thus, given that $VH_h = \frac{EH_h}{CPIH_h}$, using the superscript 0 and 1 to denote the two situations before and after change, we have

$$\frac{EH_h^0}{CPIH_h^0} = \frac{EH_h^1 - CV_h}{CPIH_h^1} \text{ and hence}$$

$$CV = EH_h^1 - \left(\frac{CPIH_h^0}{CPIH_h^1} \right) EH_h^0$$

Thus, using the same approach we have

$$\frac{EH_h^0 + EV_h}{CPIH_h^0} = \frac{EH_h^1}{CPIH_h^1} \text{ and hence}$$

$$EV = \left(\frac{CPIH_h^0}{CPIH_h^1} \right) EH_h^1 - EH_h^0$$

CV and EV therefore can be used to find the effect of policy shock on households' welfare.

iii. Derivation of Factor Demand Function

1. $\max_{QA_a, QF_{f,a}} imise \;\; p_a = PVA_a QA_a - \sum_f PF_f QF_{f,a}$ Subject to;

2. $$QA_a = ad_a \prod_f QF_{f,a}^{a_{f,a}}$$

The first equation represents the firm's profit to be maximized. The first term in the right-hand side of this equation is sales of its outputs; the second is factor cost for production.

In order to solve this maximization problem, we define the Langrangian with Langrange multipliers of l_a as follows.

3. $K_a(QA_a, QF_{f,a}, l_a) = \left[PVA_a QA_a - \sum_f PF_f QF_{f,a}\right] + l\left[ad_a \prod_f QF_{f,a}^{a_{f,a}} - QA_a\right]$

Because this problem usually has an interior solution, we can obtain the following first-order conditions, which an optimal solution suffices:

4. $\frac{\partial K_a}{\partial QA_a} = PVA_a - l_a = 0$

5. $\frac{\partial K_a}{\partial QF_{f,a}} = -PF_f + \frac{l a_{f,a}}{QF_{f,a}} ad_a \prod_f QF_{f,a}^{a_{f,a}} = 0$

6. $\frac{\partial K_a}{\partial l_a} = ad_a \prod_f QF_{f,a}^{a_{f,a}} - QA_a$

Solving equation (4) for l

7. $l_a = PVA_a$

Solving equation (6) for QA_a

8. $QA_a = ad_a \prod_f QF_{f,a}^{a_{f,a}}$

Solving equations (5) for PF_f

9. $PF_f = \dfrac{l\, a_{f,a}}{QF_{f,a}} ad_a \prod_f QF_{f,a}^{a_{f,a}} = 0$

Substituting equation (6) and (7) in equation (9), we obtain factor demand function:

10. $PF_f = \dfrac{PVA_a QA_a a_{f,a}}{QF_{f,a}}$

iv. Derivation of Import-Domestic Demand Ratio

$$QQ_c = aq_c.\left[(1-dq_c).QD_c^{-rq_c} + dq_c.QM_c^{-rq_c}\right]^{\frac{-1}{rq_c}}$$

$$PQ_c.QQ_c = PD_c.QD_c + PM_c.QM_c$$

$$\frac{\partial QQ_c}{\partial QD_c} = -\frac{1}{r\,q_c}.aq_c\left[(1-d\,q_c).QD_c^{-r\,q_c} + dq_c.QM_c^{-r\,q_c}\right]^{\frac{1}{r\,q_c}-1}\left[(-r\,q_c)(1-d\,q_c).QD_c^{-r\,q_c}\right]$$

$$\frac{\partial QQ_c}{\partial QD_c} = (1-d\,q_c).aq_c.\left[(1-d\,q_c).QD_c^{-r\,q_c} + d\,q_c.QM_c^{-r\,q_c}\right]^{-\left(\frac{1+r\,q_c}{r\,q_c}\right)}\left[QD_c\right]^{-(r\,q_c+1)}$$

$$\frac{\partial QQ_c}{\partial QD_c} = \frac{(1-d\,q_c)}{aq_c^{r\,q_c}}.aq_c^{1+r\,q_c}.\left[(1-d\,q_c).QD_c^{-r\,q_c} + d\,q_c.QM_c^{-r\,q_c}\right]^{-\left(\frac{1+r\,q_c}{r\,q_c}\right)}.\frac{1}{QD_c^{r\,q_c+1}}$$

$$\frac{\partial QQ_c}{\partial QD_c} = \frac{(1-d\,q_c)}{aq_c^{r\,q_c}}\left[aq_c\left[(1-d\,q_c).QD_c^{-r\,q_c} + d\,q_c.QM_c^{-r\,q_c}\right]^{\frac{-1}{r\,q_c}}\right]^{1+r\,q_c}.\frac{1}{QD_c^{r\,q_c+1}}$$

$$\frac{\partial QQ_c}{\partial QD_c} = \frac{(1-d\,q_c)}{aq^{r\,q_c}}\left[QQ_c\right]^{1+r\,q_c}.\frac{1}{QD_c^{r\,q_c+1}}$$

$$\frac{\partial QQ_c}{\partial QD_c} = \frac{(1-d\,q_c)}{aq_c^{r\,q_c}}\left[\frac{QQ_c}{QD_c}\right]^{1+r\,q_c}$$

Likewise we can get

$$\frac{\partial QQ_c}{\partial QM_c} = \frac{d\,q_c}{aq_c^{r\,q_c}}\left[\frac{QQ_c}{QM_c}\right]^{1+r\,q_c}$$

$$MRS = \frac{\partial QQ_c / \partial QD_c}{\partial QQ_c / \partial QM_c} = \frac{1-d\,q_c}{d\,q_c}\left[\frac{QM_c}{QD_c}\right]^{1+r\,q_c}$$

$$\frac{PD_c}{PM_c} = \frac{1-d\,q_c}{d\,q_c}\left[\frac{QM_c}{QD_c}\right]^{1+r\,q_c}$$

$$\frac{PD_c}{PM_c}.\frac{d\,q_c}{1-d\,q_c} = \left[\frac{QM_c}{QD_c}\right]^{1+r\,q_c}$$

$$\frac{QM_c}{QD_c} = \left[\frac{PD_c}{PM_c}.\frac{d\,q_c}{1-d\,q_c}\right]^{\frac{1}{1+r\,q_c}}$$

Let $s\,q_c = \dfrac{1}{1+\,r\,q_c}$

$$\frac{QM_c}{QD_c} = \left[\frac{PD_c}{PM_c}.\frac{d\,q_c}{1-d\,q_c}\right]^{s\,q_c}$$

v. <u>Derivation of Export-Domestic Supply Ratio</u>

$$QX_c = ax_c\left[(1-d\,x_c)QD_c^{r\,x_c} + d\,x_c\,QE_c^{r\,x_c}\right]^{\frac{1}{r\,x_c}}$$

$$PX_c QX_c = PD_c QD_c + P\,E_c QE_c$$

$$\frac{\partial QX_c}{\partial QD_c} = \frac{1}{r\,x_c}ax_c\left[(1-d\,x_c)QD_c^{r\,x_c} + dx_c QE_c^{r\,x_c}\right]^{\frac{1}{r\,x_c}-1}\left[(r\,x_c)(1-d\,x_c)QD_c^{r\,x-1_c}\right]$$

$$\frac{\partial QX_c}{\partial QD_c} = (1-d\,x_c)ax_c\left[(1-d\,x_c)QD_c^{r\,x_c} + d\,x_c.QE_c^{r\,x_c}\right]^{\left(\frac{1-r\,x_c}{r\,x_c}\right)}\left[QD_c\right]^{(r\,q_c-1)}$$

$$\frac{\partial QX_c}{\partial QD_c} = \frac{(1-d\,x_c)}{ax_c^{-r\,x_c}}ax_c^{1-r\,x_c}\left[(1-d\,x_c).QD_c^{r\,x_c} + d\,x_c.QE_c^{r\,x_c}\right]^{\left(\frac{1-r\,x_c}{r\,x_c}\right)}.QD_c^{r\,x_c-1}$$

$$\frac{\partial QX_c}{\partial QD_c} = \frac{(1-d\,x_c)}{ax_c^{-r\,x_c}}\left[ax_c\left[(1-d\,x_c).QD_c^{r\,x_c} + d\,x_c.QE_c^{r\,x_c}\right]^{\frac{1}{r\,x_c}}\right]^{1-r\,x_c}.QD_c^{r\,x_c-1}$$

$$\frac{\partial QX_c}{\partial QD_c} = \frac{(1-d\,x_c)}{ax^{-r\,x_c}}\left[QX_c\right]^{1-r\,x_c}.QD_c^{r\,x_c-1}$$

$$\frac{\partial QX_c}{\partial QD_c} = \frac{(1-d\,x_c)}{ax_c^{-r\,x_c}}\left[\frac{QD_c}{QX_c}\right]^{r\,x_c-1}$$

Likewise we can get

$$\frac{\partial QX_c}{\partial QE_c} = \frac{d\ x_c}{a x_c^{-r\ x_c}} \left[\frac{QE_c}{QX_c} \right]^{1+r\ q_c}$$

$$MRS = \frac{\partial QX_c \big/ \partial QD_c}{\partial QX_c \big/ \partial QE_c} = \frac{1-d\ x_c}{d\ x_c} \left[\frac{QD_c}{QE_c} \right]^{r\ x_c - 1}$$

$$\frac{PD_c}{PE_c} = \frac{1-d\ x_c}{d\ x_c} \left[\frac{QD_c}{QE_c} \right]^{r\ x_c - 1}$$

$$\frac{PD_c}{PE_c} . \frac{d\ x_c}{1-d\ x_c} = \left[\frac{QD_c}{QE_c} \right]^{r\ x_c - 1}$$

$$\frac{QD_c}{QE_c} = \left[\frac{PD_c}{PE_c} . \frac{d\ x_c}{1-d\ x_c} \right]^{\frac{1}{r\ x_c - 1}}$$

Let $s\ x_c = \dfrac{1}{r\ x_c - 1}$

$$\frac{QD_c}{QE_c} = \left[\frac{PD_c}{PE_c} . \frac{d\ x_c}{1-d\ x_c} \right]^{s\ x_c}$$

Appendix 3:

Saudi Model Equations, Variables, Sets and Parameters

i. List of Saudi Model Equations

Eq. NO in GAMS	Model Equations	NO of Eqns
1	$QA_a = ad_a \prod_{f \in F} QF_{fa}^{\alpha_{fa}}$	8
2	$QINT_{ca} = ir_{ca}\ QA_a$	64
3	$QF_{fa} PF_f PFD_{fa} = \alpha_{fa} PVA_a QA_a$	24
4	$QX_c = \sum_{a \in A} \theta_{ac} QA_a$	8
5	$PA_a = \sum_{c \in C} \theta_{ac}\ PX_c$	8
6A	$PA_a . QA_a = TCST_a$	7
6B	$PA_a . QA_a = TCST_a + PROF_a$	1
7	$TCST_a = FCST_a + MCST_a + ACTAX_a$	8
8	$FCST_a = PVA_a . QA_a$	8
9	$MCST_a = \sum_{c \in C} PQ_c . QINT_{ca}$	8
10	$QQ_c = aq_c \left((1 - dq_c) QD_c^{-rq_c} + dq_c QM_c^{-rq_c} \right)^{-1/rq_c}$	6
11	$QM_c / QD_c = [(dq_c / 1 - dq_c)(PD_c / PM_c)]^{sq_c}$, $sq_c = 1/1 + rq_c$, $sq_c > 0$, $rq_c > -1$	6
12	$PQ_c QQ_c = (PD_c QD_c + PM_c QM_c)(1 + tq_c)$	6
13	$PM_c = (1 + tm_c) PWM_c EXR$	6
14	$QQ_c = QD_c$	1
15	$PQ_c QQ_c = PD_c QD_c (1 + tq_c)$	1
16	$QX_c = ax_c \left((1 - dx_c)\ QD_c^{rx_c} + dx_c QE_c^{rx_c} \right)^{1/rx_c}$	5
17	$QD_c / QE_c = [(dx_c / 1 - dx_c)(PD_c / PE_c)]^{sx_c}$	5
18	$PX_c QX_c = PD_c QD_c + PE_c QE_c$	5
19	$PE_c = (1 - te_c) PWE_c EXR$	5
20	$QX_c = QD_c$	2
21	$PX_c QX_c = PD_c QD_c$	2

22	$AVCST_c = AVCST_a$, where $AVCST_a = TCST_a / QA_a$	1
23	$PROF_c = PROF_a$,	1
24	$PROF_c = PX_c QX_c - AVCST_c QX_c$	1
25	$QX_c = QD_c + (QE_c + QEODUM)$	1
26	$PX_c QX_c = PD_c QD_c + PE_c\ (QE_c + QEODUM)$	1
27	$QQ_c = QD_c$	1
28	$PQ_c = PD_c(1 - subo)$	1
29	$(QE_c + QEODUM) = ROWOD - ROWOS$	1
30	$ROWOD = \overline{ROWOD}\left[(1+to)PWE_c\right]^{-e_{rowod}}$	1
31	$ROWOS = \overline{ROWOS} \cdot PWE_c^{e_{rowso}}$	1
32	$(QE_c + QEODUM) \cdot e = ROWOD \cdot e_{rowod} + ROWOS \cdot e_{rowos}$	1
33	$PE_c = AVCST_c / (1 - 1/e)$	1
34	$PWE_c = PE_c / EXR$	1
35	$YF_{hf} = shry_{hf}\left(\sum_{a \in A} FDP_{lab,a} PF_{lab} QF_{lab,a} + \sum_{a \in ANO} FDP_{cap,a} PF_{cap} QF_{cap\,a}\right)$	6
36	$YLABH_h = \sum_{f \in LAB} YF_{h,f}$	2
37	$YF_{gcap} = \sum_{a \in AO}\left(FDP_{cap,a} PF_{cap} QF_{cap,a} + PROF_a\right)$	1
38	$YH_h = \sum_{f \in F} YF_{hf} + TR_{hg} CPI + EXR \cdot TR_{hr}$	2
39	$DTAX_h = ty_h\left(YH_h - tp_h YLABH_h - OTR_{g,h}\right)$	2
40	$DIH_h = YH_h - DTAX_h - tp_h YLABH_h - OTR_{g,h}$	2
41	$DIH_h = EH_h + SH_h + TR_{r,h}$	2
42	$TR_{r,h} = mpt_h DIH_h$	2
43A	$SH_h = MPS_h\left(DIH_h - TR_{r,h}\right)$	2
43B	$MPS_h = \mathrm{mpsin}_h\left(1 + MPSADJ \cdot \mathrm{mpsdum}_h\right)$	2
44	$QH_{c,h} = b_{c,h} EH_h / PQ_c$	16
45	$UTILH_h = \prod_{c \in C}\left(QH_{c,h} / b_{c,h}\right)^{b_{c,h}}$	2
46	$CPIH_h = \prod_{c \in C} PQ^{b_{c,h}}$	2

47A	$CPI = \sum_{h\in H} m_h CPIH_h$	1
47B	$m_h = \dfrac{UTILH_h}{\sum_{h\in H} UTILH_h}$	2
48	$QINV_c = \mathrm{inv}_c\, IADJ$	8
49	$GBS = YF_{g,cap} + EXR \cdot TR_{g,r} - TR_{r,g} + \sum_{a\in A} ACTAX_a$ $+ \sum_h \left(DTAX_h + tp_h YLAB_h + OTR_{gh} - CPI \cdot TR_{h,g} \right)$ $+ \sum_{c\in C} tq_c PDQD_c + \sum_{c\in CM} tq_c PM_c QM_c + \sum_{c\in CM} tm_c EXR \cdot PWM_c QM_c$ $- \sum_{c\in CE} te_c EXR \cdot PWE_c - \sum_{c\in CO} subo \cdot PDQD_c - \sum_{c\in C} PQ_c . QG_c$	1
50	$\sum_{a\in A} QF_{fa} - QFU_f = QFS_f$	3
51	$QQ_c = \sum_{a\in A} QINT_{ca} + \sum_{h\in H} QH_{ch} + QG_c + QINV_c$	8
52	$BOP = \left(\sum_{c\in CM} PWM_c QM_c + \sum_{i\in I} TR_{ri} / EXR \right)$ $- \left(\sum_{c\in CE} PWE_c QE_c + \sum_{c\in CO} PWE_c \left(QE_c + QEDUM \right) + \sum_{i\in I} TR_{ir} \right)$	1
53	$WALR = \sum_{h\in H} SH_h + GBS + EXR \cdot BOP - \sum_{c\in C} PQ_c QINV_c$	1

ii. Endogenous Variables and Description

Variable	Definition	NO
$AVCST_{co}$	average cost of producing commodity c	1
BOP	balance of payment (foreign savings) in foreign currency	1
$CPIH_h$	Consumer price index for household	2
DIH_h	Disposable income of household h	2
$(EPSI_{co})$	price elasticity perceived by the country for demand for its oil by ROW	1
EXR	foreign exchange rate (domestic currency per unit of foreign currency, exogenous and BOP is endogenous)	1
$FCST_a$	factor input cost of activity a	8
FPD_{fa}	Wage distortion for factor f in activity a	1
GBS	government budget surplus	1
$IADJ$	Investment adjustment factor	1
$MCST_a$	material input cost of activity a	8
MPS_h	marginal (and average) propensity to save for household h (exogenous and $IADJ$ is endogenous)	2
MU_h	Weight of household utility in CPI	2
PA_a	activity price (calculated from the cost side using PVA and intermediate input cost)	
PWE_c	world market price of exports including oil	1
QA_a	level of activity a = quantity of output produced by activity	8
QD_c	quantity sold of domestically of domestic output c	8
QE_c	quantity of exports for commodity c	6
QF_{fa}	quantity demanded of factor f by activity a	24
QFU_f	Excess supply of factor f	3
QH_{ch}	quantity consumed of commodity c by household h	16
$QINT_{ca}$	quantity of commodity c as intermediate input to activity a	64
$QINV_c$	quantity of investment demand for commodity c	8
QM_c	quantity of imported commodity c	6

QQ_c	quantity of good supplied domestically (composite supply)	8
QX_c	quantity of domestic output of commodity c	8
$ROWOD$	total demand for oil by the ROW	1
$ROWOS$	total supply of oil by the ROW	1
$subo$	subsidy rate for domestic oil price	2
SH_h	Total saving of household h	2
$TCST_a$	total cost of activity a	8
$TR_{ROW\ h}$	Household transfer abroad	2
$UTILH_h$	Household utility from consumption	2
$WALR$	dummy variable (zero at equilibrium)	1
YF_{if}	Gross income of household h from factor f	7
YH_h	Total gross Income of household h	2
$YLABH_h$	Labor income to household h	2

Summary of Number of Endogenous, Variables and Equations

No of endogenous variables: 304
No of model equations: 275
No of closure equations: 29
consisting:

EXR & BOP:	1	
S-I:	1	
CAP market:	9	(8 activity + 1 capital)
SLB market:	9	(8 activity + 1 labor)
NSLAB market:	9	(8 activity + 1 labor)

Other Variables Description

PD_c	price of demand output paid by domestic consumers
PE_c	export price (received by the domestic producer, in domestic currency)
PWM_c	world market price of imports
PX_c	price received by producer for commodity c
PF_f	price of (or rate of return to) factor f
PM_c	import price (paid by domestic user, in domestic currency)
PQ_c	price of the composite commodity c paid by domestic consumers
$PROF_a$	the profit from producing good a ; $PROF_a = PROF_c \ when \ c = a$
PVA_a	Price of value added
LAB_f	Labor
$CAPT_f$	capital

iv. Sets and Sub-Sets Table

Sets	Components
$a \in A$	All activities, e.g. consisting of (as in the Saudi 2000 IO Table) Agriculture, crude oil, refinery, manufacture, utility, construction, tradable services, non-tradable services.
$a \in AO \subset A$	oil activity: crude oil
$a \in ANO \subset A$	Non-oil activity: agriculture, refinery, manufacture, utility, construction, tradable services and non-tradable services.
$c \in C$	Commodities, which usually maps-one-to-one to A
$c \in CO \subset C$	Oil: crude oil
$c \in CNO \subset C$	Non-oil commodity: agriculture, refinery, manufacture, utility, construction, tradable services and non-tradable services.
$c \in CM \subset CNO$	Importable commodities: agriculture, refinery, manufacture, construction, tradable services.
$c \in CNM \subset CNO$	Non-Importable commodities: utility, crude oil, non-tradable services.
$c \in CE \subset CNO$	Exportable commodities, **excluding oil**: agriculture, refinery, manufacture, construction, tradable services.
$c \in CNE \subset CNO$	Non-Exportable commodities: utility, non-tradable services.
$f \in F$	Primary factors, $F = \{slab, nslab, cap\}$; for Saudi labor and non-Saudi labor and capital respectively.
$i \in I$	Institutions: Households: $h \in H \subset I$; $H = \{shh, nshh\}$ Saudi households and non-Saudi households, Government: $g \in I$ Rest of the world: $r \in I$

iv. Exogenous Variables and Notations

CPI	consumer price index
INV_c	bench investment levels or base-year investment demand (can be endogenous)
QFS_f	supply of factor *f*
QG_c	government commodity demand
tm_c	Import tariff rate
to	tax rate on crude oil in the world market.
tq_c	sales tax rate
TR_{ij}	transfer from

v. Parameters

Parameters	Description
ad_a	production function efficiency parameter
aq_c	shift parameter for composite supply (Armington) function.
ax_c	shift parameter for output transformation (CET) function
ir_{ca}	quantity of c as intermediate input per unit of activity a
$shry_{hf}$	share for household h in income of factor f
b_{ch}	share of consumption spending of household h on commodity c
e_{rowos}	price elasticity supply of oil by the ROW
e_{rowod}	price elasticity demaad of oil by the ROW
q_{ac}	yield of commodity c per unit of activity a
dq_c	share parameter for the composite good
dx_c	share parameter for output transformation
s_{qc}	elasticity of substitution for the composite good ($1 < s_{qc} < \infty$)
sx_c	elasticity of transformation for output transformation $\infty < sx_c < 0$)
rq_c	Exponent of Armington function (CES) $rq_c = 1/sq_c - 1, (-1 < rq_c < \infty)$
rx_c	exponent used in the CET aggregation function $rx_c = 1/sx_c + 1, (1 < rx_c < \infty)$
inv_c	base-year quantity of investment demand for commodity
$mp\sin_h$	Initial marginal propensity to consume
$mpsdum_h$	0,1 dummy: 1= for those H that saving changes, 0 otherwise
mpt_h	marginal propensity to transfer abroad
pe_h	tax rate for pension
ty	Direct tax rate
$QEODUM$	shift dummy for Saudi oil exports

Appendix 4

GAMS Codes

```
= == = == = = = = = = == == == == Model Features= = = == = = == =  = = = =  = =
    8 goods, 8 activities, 3 factors, 2 household, 1 government, 1 row,
    1 Save-Investment;
    market power in the world oil markets;
    no firms amongst institutions.

 = === == = = = = = = = = = = = = = = === SETS= = = = ==  = == = = = = = = = =  = = =
      AC  "the global set including all items"
     AGRI-A    "Agricultural Activity"
     CRDO-A    "Crude petroleum and natural gas Activity"
     REFI-A    "Petroleum refining Activity                  "
     MANF-A    "Manufacture Activity                         "
     UTIL-A    "Electricity, gas and water supply Activity       "
     CONS-A    "Construction Activity                        "
     TRDS-A    "Trade sector Activity                        "
     NTRDS-A   "Non-trade sector Activity                    "
     AGRI-C    "Agricultural commodity                       "
     CRDO-C    "Crude petroleum and natural gas commodity        "
     REFI-C    "Petroleum refining commodity                 "
     MANF-C    "Manufacture commodity                        "
     UTIL-C    "Electricity gas and water supply commodity       "
     CONS-C    "Construction commodity                       "
     TRDS-C    "Trade sector commodity                       "
     NTRDS-C   "Non-trade sector commodity                   "
     SLAB      "Saudi labour factor of production            "
     NSLAB     "Non-Saudilabour factor of production             "
     CAP       "capital factor of production                 "
     NSHH      "Non-Saudi household                          "
     SHH       "Saudi household                              "
     GOV       "government                                   "
     ROW       "rest of the world                            "
     ACTAX     "Activity tax                                 "
     INDTAX    "Indirect tax                                 "
     IMPTAX    "Import tax                                   "
     S-I       "savings-investment                           "
     TOTAL     "total account in SAM                         "
 = = = == == = = = === Generating the Specific Sets and Subsets == = = = = = === == =

      ACNT(AC)   "all elements in AC except total"
      A(AC)      "all activities"
          /AGRI-A, CRDO-A, REFI-A, MANF-A, UTIL-A, CONS-A, TRDS-A,
      RDS-A
     ANO(A)     "all activities except oil"
     /AGRI-A, REFI-A,MANF-A, UTIL-A, CONS-A, TRDS-A, NTRDS-A/
     AO(A)      "oil is equated to the Crude petroleum and natural gas Activities"
     /CRDO-A/
    C(AC)      "all commodities"
    /AGRI-C, CRDO-C, REFI-C, MANF-C, UTIL-C, CONS-C, TRDS-,
      NTRDS-C/
    CNO(C)     "all commodities except oil"
     /AGRI-C, REFI-C, MANF-C, UTIL-C, CONS-C, TRDS-C, NTRDS-C /
```

```
CO(C)      "oil is equated to the crude petroleum and natural gas
commodities"
       /CRDO-C/
CE(C)      "exported commodities EXCLUDING OIL"
       /AGRI-C, MANF-C, CONS-C, TRDS-C,REFI-C/
CNE(C)     "non-exported commodities"
       /NTRDS-C,UTIL-C/
CM(C)      "imported commodities"
       /AGRI-C, MANF-C, CONS-C, TRDS-C,REFI-C,UTIL-C /
CNM(C)     "non-imported commodities"
       /NTRDS-C/
PROCM(C)   "protected commodities"
       / AGRI-C, REFI-C,  MANF-C/
F(AC)      "factors"            / SLAB, NSLAB, CAP /
LAB(F)     "labour"             / SLAB, NSLAB /
CAPT(F)    "capital"            / CAP /
I(AC)      "institutions    "   / SHH, NSHH,GOV, ROW /
H(I)       "households      "   / SHH,NSHH /
GOV(I)     "government"         / GOV /
ROW(I)     "rest of the world"  / ROW /
To exclude TOTAL from ACNT:
 ACNT(AC) = YES;
 ACNT('TOTAL') = NO;
   Alias sets to be used when we want to distinguish between two versions,
e.g.
* when summing y(F,F) over columns, we can write SUM(Fy(F,FAL))
ALIAS(AC,ACAL);
ALIAS(A,AAL);
ALIAS(C,CAL);
ALIAS(F,FAL);
ALIAS(I,IAL);
ALIAS(H,HAL);
ALIAS(ACNT,ACNTAL);
* SOCIAL ACCOUNTING MATRIX
* 2000 values in million KSA Ryal Modified by Chemingui
TABLE SAM(*,*)
* Sheet:      SAM-Aggregate(Sheet11)
* Range:      $A$3:$AC$31
   AGRI-A CRDO-A REFI-A MANF-A UTIL-A CONS-A TRDS-A   NTRDS-A
   AGRI-C CR DO-C REFI-C MANF-C UTIL-C CONS-C TRDS-C NTRDS-C
   SLAB   NSLAB  CAP    ACTAX

= = == = GENERATING THE TOTAL COLUMN AND ROW FOR SAM= = == ==
```

<u>*PARAMETERS*</u>

```
ctotal1(AC)   "column total, generated"
rtotal1(AC)   "row total, generated"
ctotals(AC)   "column total, from SAM"
rtotals(AC)   "row total, from SAM"
diffc1s(AC)   "ctotal1 - ctotals"
diffr1s(AC)   "rtotal1 - rtotals"
tdiffscr(AC)  "(column total - row total) for account AC in the SAM"
tdiff1cr(AC)  "ctotal1 - rtotal1"
ctotal1(ACNT)  = SUM(ACNTAL, SAM(ACNTAL,ACNT));
rtotal1(ACNT)  = SUM(ACNTAL, SAM(ACNT,ACNTAL));
```

```
ctotals(ACNT)  = SAM('TOTAL',ACNT);
rtotals(ACNT)  = SAM(ACNT,'TOTAL');
diffc1s(ACNT)  = ctotal1(ACNT) - ctotals(ACNT);
diffr1s(ACNT)  = rtotal1(ACNT) - rtotals(ACNT);
tdiffscr(ACNT) = SAM('TOTAL',ACNT) - SAM(ACNT,'TOTAL');
tdiff1cr(ACNT) = ctotal1(ACNT) - rtotal1(ACNT);
display SAM;
DISPLAY ctotal1, ctotals, rtotal1, rtotals,  diffc1s, diffr1s, tdiffscr, tdiff1cr
* GENERATING A UNIT MATRIX UMCA(A,C), WE CAN CONVERT VECTORS FROM ACTIVITY
* SPACE, E.G. VA(A), TO COMMODITY SPACE, E.G. V(C).
* FOR EXAMPLE, VA(A) CAN BE CONVERTED TO VC(C) USING
* VC(C)=SUM(A,UMAC(C,A)*VA(A)
PARAMETER
UMAC(C,A)  "unit matrix for converting vectors from A space to C space   "
UMCA(A,C)      "unit matrix for converting vectors from C space to A space
UMCA(A,C)=SAM(A,C)/SUM(AAL,SAM(AAL,C));
UMAC(C,A)=0;
UMAC('AGRI-C ', 'AGRI-A')=1;
UMAC('CRDO-C',  'CRDO-A')=1;
UMAC('REFI-C',  'REFI-A')=1;
UMAC('MANF-C',  'MANF-A')=1;
UMAC('UTIL-C',  'UTIL-A')=1;
UMAC('CONS-C',  'CONS-A')=1;
UMAC('TRDS-C',  'TRDS-A')=1;
UMAC('NTRDS-C', 'NTRDS-A')=1;
*Display UMAC,UMCA;

* PARAMETERS AND EXOGENOUS VARIABLES
PARAMETERS
ACTAX(A)
    "activity tax for activity a     "
ad(A)          "shift in the production fn for activity a       "
alpha(F,A)     "elasticity of factor f in the production fn for activity a       "
aq(C)          "shift parameter in CES aggregation for commodity c       "
ax(C)          "shift parameter in CES transformation for commodity c       "
beta(C,H)      "share of households total spending on commodity c       "
CPI            "consumer price index       "
*cwts(H)        "weight of commodity c in the CPI       "
deltaq(C)      "share parameter in CES aggregation for commodity c       "
deltax(C)      "share parameter in CES transformation for commodity c       "
erowod         "price elasticity demand for oil by the ROW       "
erowos         "price elasticity supply of oil by the ROW       "
ir(C,A)        "IO coeff: qnty of c as intermediate input per unit of activity a"
inv(C)         "base-year qnty of investment demand for commodity c     "
mpsin(H)       "Initial marginal propensity to consume"
mpsdum(H)      "0-1 dummy: 1= for those H that saving changes, 0 otherwise    "
mpt(H)         "marginal propensity to transfer abroad"
QEODUM         "shift dummy for Saudi oil exports    "
QFS(F)         "total supply of factor f     "
QG(C)          "government demand for commodity c (in quantity)     "
rhoq(C)        "exponent parameter in the CES aggregation for commodity c       "
rhox(C)        "exponent parameter in the CES transformation for commodity    c"
ROWODI(CO)     "shift parameter in demand for oil by the ROW  "
ROWOSI(CO)     "shift parameter in supply of oil by the ROW     "
sdo            "DOMESTIC OIL PRICE SUBSIDY "
```

```
shry(I,F)       "Share for institution I in income of factor F       "
theta(A,C)      "yield coeff: yield of output c per unit of activity a       "
te(C)           "EXPORT SUPSIDY OR TAX RATE FOR COMMODITY C   "
tm(C)           "import tariff rate for commodity c    "
tq(C)           "sales tax rate for commodity c  "
to              "crude oil tax in world market    "
tp(H)           "tax rate for pension "
ty(H)           "income tax for householld h   "
iterlim         " iteration"
* ENDOGENOUS VARIABLES
VARIABLES
AVCST(CO)     "average cost of producing comodity c "
BOP           "balance of payment (foreign savings) in foreign currency)  "
CPIH(H)       "HH CPI "
DIH(H)        "disposable income of households   "
DTAX(H)       "direct tax paid by households     "
EH(H)         "HH EXPENDITURE ON CONSUMPTION "
EPSI(CO)      "price elasticity of demand for Saudi oil by the ROW    "
EXR           "exchange rate (dom. currency per unit of for. currency)    "
FCSTA(A)      "factor input cost of activity a    "
FPD(F,A)      "wage distortion factor for factor F in activity a    "
GBS           "government budget surplus (or deficit)    "
GR            "government revenue  "
tqadj         "adjustment to sales tax  rate   "
tyadj         "adjustment to income tax rate     "
MU(H)         "Weight of household utility in the CPI    "
IADJ          "investment adjustment factor     "
MCSTA(A)      "material input cost of avtivity a     "
MPS(H)        "marginal (and average) propensity to save for household h    "
MPSADJ        "Average Marginal propensity to consume"
OTR(I,IAL)    "other transfers      "
PA(A)         "price of activity a       "
PD(C)         "domestic price of domestic output c       "
PE(C)         "export price for c (domestic currency)       "
PF(F)         "average price of factor F       "
PM(C)         "import price for c (domestic currency)       "
PQ(C)         "composite commodity price for c       "
PROFA(AO)     "profit of activity a in A space       "
PROFC(CO)     "profits of activity a in C space       "
PVA(A)        "value-added price for activity a       "
PWE(C)        "export (world) price for c (foreign currency)       "
PWM(C)        "import (world) price for c (foreign currency)       "
PX(C)         "producer price for commodity c       "
QA(A)         "level of activity a = quantity of output produced by the activity"
QD(C)         "quantity sold domestically of domestic output c    "
QE(C)         "quantity of exports for commodity c    "
QF(F,A)       "quantity demanded of factor f from activity a     "
QFU(F)        "excess sup. of factor CAP (e.g. unemployment)    "
QH(C,H)       "quantity consumed of commodity c by households h   "
QINT(C,A)     "qnty of commodity c as intermediate input to activity a      "
QINV(C)       "quantity of investment demand for commodity c    "
QM(C)         "quantity of imports of commodity c      "
QQ(C)         "quantity of goods supplied domestically (composite supply)    "
QX(C)         "quantity of domestic output of commodity c     "
ROWOD(CO)     "total demand for oil by the ROW    "
```

308 ROWOS(CO) "total supply of oil by the ROW "
309 SH(H) "total savings of households "
310 TCSTA(A) "total cost of activity a "
311 TR(I,IAL) "transfer from institution ial to institution i "
312 UTILH(H) "HUSEHOLD UTILITY FROM CONSUMPTION "
313 WALR "dummy variable (zero at equilibrium) "
314 YF(I,F) "gross income of households from factor "
315 YH(H) "total gross income of household h "
316 YLABH(H) "LABOUR INCOME "
320 EQUATIONS
322 EQUATION NAME
ABDULLAH: WRITE THE DESCRIPTIONS HERE. I HAVE CHANGED THE NO.S

EQUATIONS

EQ1 "level of activity a = quantity of output produced by the activity"
EQ2 "qnty of commodity c as intermediate input to activity a "
EQ3 "quantity demanded of factor f from activity a "
EQ4 "quantity of domestic output of commodity c "
EQ5 "price of activity a "
EQ6A "total revenue equals total cost for non-oilcommodity"
EQ6B "total revenue equals total cost plus oil profit for oil commmdity"
EQ7 "total cost of activity a "
EQ8 "factor input cost of activity a "
EQ9 "material input cost of avtivity a "
EQ10 "quantity of goods supplied domestically (composite supply) "
EQ11 "quantity of imports of commodity c "
EQ12 "composite commodity price for c "
EQ13 "import price for c (domestic currency) "
EQ14 "Tranformation for non exported commodity c"
EQ15
EQ16 "quantity of domestic output of commodity c "
EQ17 "quantity of exports for commodity c "
EQ18 "producer price for commodity c "
EQ19 "export price for c (domestic currency) "
EQ20 " output equal domestic quantity "
EQ21 "Value output equal value domestic commidty in case no export"
EQ22 "average cost of producing comodity c "
EQ23 "factor input cost of activity a "
EQ24 "profit of activity a in A space "
EQ25 "profits of activity a in C space "
EQ26 "Output value for commodity c"
EQ27 "Composite version for non imported commodity c"
EQ28 "composite price for oil"
EQ29 "export of oil"
EQ30 "Rest of the world oil demand"
EQ31 "world oil supply"
EQ32 "price elasticity demand for oil by the ROW "
EQ33 "price elasticity demand for oil by the ROW "
EQ34 "domestic oil price"
EQ35 "world oil price"
EQ36 "labor income"
EQ37 "facor income"
EQ38 "houshold incme from factor"
EQ39 "direct tax income"
EQ40 "disposable income"

EQ41 "disposable income"
EQ42 "transfer from hosehold to rest of the world"
EQ43A "household savings"
EQ43B "marginal propensity to save"
EQ44 "household consumption"
EQ45 "utilty function"
EQ46 "Consumer price index for each household h"
EQ47 "HUSEHOLD UTILITY FROM CONSUMPTION "
EQ48 "Quantity of investment demand for commodity c"
EQ49 "government budget surplus (or deficit) "
EQ49A "government revenue "
EQ50 "factor supply"
EQ51 "Market equlibrium condition of composite commodity c"
EQ52 "balance of paymnet"
EQ53 "Saving investment balance with WALR dummy to be zero"
EQ54 "Weight of househol

== = === == = ====CHOICE OF MODELLING THE OIL SECTOR == = = = = =

The model can in principle be solved with or without imposing oil supply quota
Define a dummy OILCLOS = 1 or 2 so that:
if OILCLOS = 1:- there is no supply quota and the oil price is fixed by
the country's monopoly behaviour;
if OILCLOS = 2:- supply is fixed at the current level by quota and the oil
price is determined by the world market.
Choose the desired case by fixing OILCLOS below:

WE DO NOT USE THE QUOTA OPTION IN THIS EXERCISE SO IT IS NOT DEVELOPED BELOW.

OILCLOS = 1 activates the markup equation.

* TO ALLOW FOR OIL EXPORT SHOCK, WE HAVE DEFINED A DUMMY QEODUM WHICH IS A
DDED TO QE(CO). QEODUM IS INITIALLY SET TO ZERO.
* WE CAN SET QEODUM SO AS TO ALLOW FOR AN EXOGENOUS 10% RISE IN OIL EXPORT
S, AND SEE HOW IT AFFETCTS THE ECONOMY

```
406  SCALAR OILCLOS "oil market closure" /1/;
= = = = = = = = = = =EXPRESSIONS FOR THE EQUATIONS= = == = = = === =
410  EQ1(A) .. QA(A) =E= ad(A)*PROD(F, QF(F,A)**alpha(F,A));
412  EQ2(C,A) .. QINT(C,A) =E= ir(C,A)*QA(A);
414  EQ3(F,A) .. PF(F)*FPD(F,A)*QF(F,A) =E= alpha(F,A)*PVA(A)*QA(A);
416  EQ4(C) .. QX(C) =E= SUM( A, theta(A,C)*QA(A) );
418  EQ5(A) .. PA(A) =E= SUM(C, theta(A,C)*PX(C));
420  EQ6A(ANO) .. PA(ANO)*QA(ANO) =E= TCSTA(ANO);
422  EQ6B(AO) .. PA(AO)*QA(AO) =E= TCSTA(AO) + PROFA(AO);
424  EQ7(A) .. TCSTA(A) =E= FCSTA(A) + MCSTA(A) + ACTAX(A);
426  EQ8(A) .. FCSTA(A) =E= PVA(A)*QA(A);
428  EQ9(A) .. MCSTA(A) =E= SUM(C, QINT(C,A)*PQ(C));
430  EQ10(C)$CM(C) .. QQ(C) =E= aq(C)*
 431    (deltaq(C)*QM(C)**(-rhoq(C))+(1-deltaq(C))*QD(C)**(-rhoq(C)))**(-1/rhoq(C));
433  EQ11(C)$CM(C).. QM(C)/QD(C) =E=
 434       ( ( deltaq(C)/(1-deltaq(C)) )*(PD(C)/PM(C)) )**(1/(1+rhoq(C)));
436  EQ12(C)$CM(C) .. PQ(C)*QQ(C)
```

```
         =E= (PD(C)*QD(C) + PM(C)*QM(C))*(1 + tqadj*tq(C));
EQ13(C)$CM(C) .. PM(C) =E= (1 + tm(C))*EXR*PWM(C);
EQ14(C)$CNM(C) .. QQ(C) =E= QD(C);
EQ15(C)$CNM(C) .. PQ(C)*QQ(C) =E= PD(C)*QD(C)*(1 + tqadj*tq(C));
EQ16(C)$CE(C) .. QX(C) =E= ax(C)*
  (deltax(C)*QE(C)**(rhox(C)) + (1-deltax(C))*QD(C)**(rhox(C)) )**(1/rhox(
C));
EQ17(C)$CE(C) .. QE(C)/QD(C) =E=
          ( (PE(C)/PD(C) )*((1-deltax(C))/deltax(C)) )**(1/(rhox(C)-1) );
EQ18(C)$CE(C) .. PX(C)*QX(C) =E= PD(C)*QD(C) + PE(C)*QE(C);
EQ19(C)$CE(C) .. PE(C) =E= (1-te(C))*EXR*PWE(C);
EQ20(C)$CNE(C) .. QX(C) =E= QD(C);
EQ21(C)$CNE(C) .. PX(C)*QX(C) =E= PD(C)*QD(C);
EQ22(CO).. AVCST(CO) =E= SUM(AO, UMAC(CO,AO)*(TCSTA(AO)/QA(AO)));
EQ23(CO).. PROFC(CO) =E= SUM(AO, UMAC(CO,AO)*PROFA(AO));
EQ24(CO) .. PROFC(CO) =E= PX(CO)*QX(CO) - AVCST(CO)*QX(CO);
EQ25(C)$CO(C) .. QX(C) =E= QD(C) + QE(C) + QEODUM;
EQ26(C)$CO(C) .. PX(C)*QX(C) =E= PD(C)*QD(C) + PE(C)*( QE(C) + QEODUM
);
EQ27(C)$CO(C) .. QQ(C) =E= QD(C);
EQ28(C)$CO(C) .. PQ(C) =E= PD(C)*(1-sdo);
EQ29(CO) .. QE(CO) + QEODUM =E= ROWOD(CO) - ROWOS(CO);
EQ30(CO) .. ROWOD(CO) =E= ROWODI(CO)*( ( (1+to)*PWE(CO) )**(-erowod) );
EQ31(CO) .. ROWOS(CO) =E= ROWOSI(CO)*( PWE(CO)**(erowos) );
EQ32(CO) .. EPSI(CO)*(QE(CO) + QEODUM) =E=
      erowod*ROWOD(CO) + erowos*ROWOS(CO);
EQ33(CO)$(OILCLOS eq 1) .. PE(CO)*(1 - 1/ EPSI(CO) ) =E= AVCST(CO);
EQ34(C)$CO(C) .. PWE(C) =E= PE(C)/EXR;
EQ35(H,F) .. YF(H,F) =E= shry(H,F)*
                    SUM(A, (PF(F)*FPD(F,A)*QF(F,A))$LAB(F)
                   + (PF(F)*FPD(F,A)*QF(F,A))$(CAPT(F) AND ANO(A)) );
EQ36(H) .. YLABH(H) =E= SUM(LAB,YF(H,LAB));
EQ37('GOV','CAP') .. YF('GOV','CAP') =E=
  SUM(AO, (PF('CAP')*FPD('CAP',AO)*QF('CAP',AO) + PROFA(AO)) );
EQ38(H) .. YH(H) =E= SUM(F,YF(H,F)) + CPI*TR(H,'GOV') + EXR*TR(H,'ROW');
EQ39(H) .. DTAX(H) =E= tyadj*ty(H)*( YH(H) - tp(H)*YLABH(H) - OTR('GOV',H)
);
EQ40(H) .. DIH(H) =E= YH(H) - DTAX(H) -  tp(H)*YLABH(H) - OTR('GOV',H);
EQ41(H) .. DIH(H) =E= EH(H) + SH(H) + TR('ROW',H);
EQ42(H) .. TR('ROW',H) =E= mpt(H)*DIH(H);
EQ43A(H) .. SH(H) =E= MPS(H)*(DIH(H) - TR('ROW',H));
EQ43B(H).. MPS(H) =E= mpsin(H)*(1 + MPSADJ*mpsdum(H));
EQ44(C,H) .. QH(C,H) =E= beta(C,H)*EH(H)/PQ(C);
EQ45(H) .. UTILH(H) =E= PROD(C, (QH(C,H)/beta(C,H))**beta(C,H) );
EQ46(H) .. CPIH(H) =E= PROD(C, PQ(C)**beta(C,H) );
EQ47 .. CPI =E= SUM( H, MU(H)*CPIH(H) ) ;
EQ48(C) .. QINV(C) =E= inv(C)*IADJ;
EQ49 .. GBS =E= YF('GOV','CAP') + TR('GOV','ROW')*EXR + SUM( A ,
ACTAX(A)
)
      + SUM( H, (tp(H)*YLABH(H) + DTAX(H) + OTR('GOV',H) ) )
      + SUM( C, (tm(C)*EXR*PWM(C)*QM(C))$CM(C) )
+ tqadj*(SUM(C, (tq(C)*PD(C)*QD(C))$CNO(C)) + SUM(C,
(tq(C)*PM(C)*QM(C))$C
M(C)))
```

```
        - (TR('ROW','GOV') + SUM( H, CPI*TR(H,'GOV') )
        + SUM( C, (te(C)*EXR*PWE(C)*QE(C))$CE(C) )
        + SUM( C, (sdo*PD(C)*QD(C))$CO(C) )
        + SUM( C, PQ(C)*QG(C) ) )
EQ49A .. GR -(YF('GOV','CAP') + TR('GOV','ROW')*EXR + SUM( A , ACTAX(A) )
        + SUM( H, (tp(H)*YLABH(H) + DTAX(H) + OTR('GOV',H) ) )
        + SUM( C, (tm(C)*EXR*PWM(C)*QM(C))$CM(C) ) )
       =E=
 tqadj*( SUM(C, (tq(C)*PD(C)*QD(C))$CNO(C)) + SUM(C,
(tq(C)*PM(C)*QM(C))$CM
   (C)) )
EQ50(F) .. QFS(F) =E= SUM(A, QF(F,A) ) + QFU(F) ;
EQ51(C) .. QQ(C) =E=
 SUM(A, QINT(C,A)) + SUM(H , QH(C,H)) + QG(C) + QINV(C);

 EQ52 .. BOP =E= SUM( CM, PWM(CM)*QM(CM) )
       + SUM( I,  TR('ROW',I)/EXR )
       - SUM( CE, PWE(CE)*QE(CE) ) - SUM(CO, PWE(CO)*(QE(CO) + QEODUM )
)
       - SUM(I, TR(I,'ROW') );
EQ53 .. WALR =E= SUM(H, SH(H)) + GBS + EXR*BOP - SUM(C,
PQ(C)*QINV(C) ) ;
EQ54(H).. Mu(H) =E= UTILH( H ) / SUM ( HAL,UTILH(HAL));
* DEFINING THE MODEL
MODEL SAUDIV1 "SAUDI Model Ver1" /ALL/ ;
* use hold fix to speed up the solution
 * This attribute tells GAMS whether to generate and send to the solver the
 * variables that are being held fixed by the .fx
SAUDIV1.HOLDFIXED = 1;

            = == = = = = = = = = == CALIBRATION = = = = = = = = = = = =
            CALIBRATING THE MODEL BY FIXING INITIAL VALUES
            WE USE A 0 TO DENOTE THE INITIAL VALUE BASED ON THE
            SAM, E.G. QA0(A) IS THE INITIAL VALUE OF QA(A), etc.

 PARAMETERS
 AVCST0(CO)
 BOP0
 CPIH0(H)
 DIH0(H)
 DTAX0(H)
 EH0(H)
 EPSI0(CO)
 EXR0
 FCSTA0(A)
 FPD0(F, A)
 GBS0
 GR0
 tqadj0
 tyadj0
 MU0(H)
 IADJ0
 MCSTA0(A)
 MPS0(H)
 MPSADJ0
```

```
OTR0(I,IAL)
PA0(A)
PD0(C)
PE0(C)
PF0(F)
PM0(C)
PQ0(C)
PROFA0(AO)
PROFC0(CO)
PVA0(A)
PWE0(C)
PWM0(C)
PX0(C)
QA0(A)
QD0(C)
QE0(C)
QF0(F, A)
QFU0(F)
QH0(C, H)
QINT0(C, A)
QINV0(C)
QM0(C)
QQ0(C)
QX0(C)
ROWOD0(CO)
ROWOS0(CO)
SH0(H)
TCSTA0(A)
TR0(I,IAL)
UTILH0(H)
WALR0
YF0(I, F)
YH0(H)
YLABH0(H)
     = == == = EXPLAINING THE PROFIT & MARKUP FOR OIL SECTOR= = = =
     In this SAM, all the income for capital in oil sector is given to the gove
     rnment.
     i.e.   SAM('GOV','CAP') GIVES TO GOV ALL THE OIL ICOME FOR CAPITAL
SAM('OI
     L-A', 'CAP').
     We have to split this into profit and cost of capital.
     We follow De Santis's approach who suggests using 40% of oil exports (PE.Q
     E) as profits (PROF).
     WE SPLIT SAM('GOV','CAP') INITO PROFITS AND COST OF CAPITAL USING
40% & 60  % SHARES.
PROFC0(CO)=.4*SAM(CO,'ROW');
*PROFC0(CNO) = 0;
PROFA0(AO) = SUM(CO,UMCA(AO,CO)*PROFC0(CO));
PARAMETER
AVCSTA0(AO)
AVCSTC0(CO)
EPSIA0(AO)
EPSIC0(CO)
MARKUPA0(AO)
```

```
* Factor input cost = SAUDI LABOR COST + NON-SAUDI LBOR COST+
CAPITAL COST
FCSTA0(ANO) = SUM(F, SAM(F,ANO));
FCSTA0(AO) = SUM(F, SAM(F,AO)) - PROFA0(AO);
* Material input cost
MCSTA0(A) = SUM(C,SAM(C,A));
* ACTIVITY TAX
ACTAX(A) = SAM('ACTAX',A);
* Total cost
TCSTA0(A) = FCSTA0(A) + MCSTA0(A) + ACTAX(A) ;
* Revenue
PARAMETER REVA0(A);
REVA0(ANO) = TCSTA0(ANO);
REVA0(AO) = TCSTA0(AO) + PROFA0(AO);
* Price, Output and Average Cost of activities
* QUANTITIES AND PRICES OF COMMODITIES
* initial commodity prices and quantities:
* Note that we should deflate the nominal values using the correct price  the value
added price of each activity as (value of activity a)/(quantity of activity a):
yield coeff: amount of commodity c per unit of activity a  PA0(A) = 1;
PX0(C) = SUM(A,UMAC(C,A)*PA0(A));
QA0(A) = REVA0(A);
theta(A,C) = SAM(A,C)/QA0(A);
QX0(C) = SUM(A, theta(A,C)*QA0(A));
AVCSTA0(AO) = (TCSTA0(AO)) / REVA0(AO);
AVCSTC0(CO) = SUM(AO,UMAC(CO,AO)*AVCSTA0(AO));
AVCST0(CO) = AVCSTC0(CO);
* Average Cost is used to define the markup
MARKUPA0(AO) = 1/AVCSTA0(AO);
* Monopoly pricing principle is used to relate Demand Elasticity to Markup
EPSIA0(AO) = 1/(1-1/MARKUPA0(AO));
EPSIC0(CO) = SUM(AO,UMAC(CO,AO)*EPSIA0(AO));
EPSI0(CO) = EPSIC0(CO);
DISPLAY FCSTA0, MCSTA0, ACTAX, PROFA0, PROFC0, REVA0, QA0, PA0
        TCSTA0, AVCSTA0, AVCSTC0, MARKUPA0, EPSIA0, EPSIC0, EPSI0;
* Oil Price is Markup on the Average Cost
* USING PE*QE = AVC*QE + PROFIT
PE0(CO) = AVCSTC0(CO)/(1-1/EPSI0(CO));
EXR0 = 1;
PWE0(CO) = PE0(CO)/EXR0;
QE0(CO) = SAM(CO,'ROW')/PE0(CO);
PD0(CO) = 1;
QD0(CO) = (SUM(A, SAM(A,CO)) - SAM(CO,'ROW'))/PD0(CO);
DISPLAY PE0, PWE0, QE0, PD0, QD0, PX0, QA0, QX0;
* we need the oil elasticities & wold demand & supply to calculate PE for
  oil
* oil demand and supply elasticities as fixed by De Santis
erowod = 0.49;
erowos = 0.212;
* using  EPSI*QE = erowod*ROWOD + erowos*ROWOS, and QE=ROWOD -
ROWOS
* to calculate the initial values of ROWOD & ROWOS
ROWOD0(CO)= QE0(CO)*(EPSI0(CO) + erowos)/(erowod+erowos);
ROWOS0(CO) = ROWOD0(CO) - QE0(CO);
*checking to see if the ratio ROWOD/QE is meaningful
```

```
PARAMETERS   TEST1(CO);
TEST1(CO) = ROWOD0(CO)/QE0(CO);
DISPLAY TEST1, ROWOD0, ROWOS0, QE0;
* oil price tax rate in the world market as fixed by De Santis
to = 2.17;
* calculating the ROW oil demand and supply shift factors
* we can use these to shock the world oil market
ROWODI(CO) = ROWOD0(CO)/(((1+to)*PWE0(CO))**(-erowod));
ROWOSI(CO) = ROWOS0(CO)/(PWE0(CO)**erowos);
DISPLAY PWE0, ROWODI, ROWOSI;
* QUANTITIES AND PRICES OF FACTORS
* No initial factor price distortion
FPD0(F,A) = 1;
* no factor unemployment allowed initially
QFU0(F) = 0;
* EMPLOYMENT FIGURES FOR YEAR 2000
PARAMETER
SLABE "NO OF SAUDI WORKERS IN EMPLOYMENT IN 2000" /2943222/
NSLABE "NO OF NON-SAUDI WORKERS IN EMPLOYMENT IN 2000"/3043763
/
PF0('SLAB') = SUM(A,SAM('SLAB',A))/SLABE;
PF0('NSLAB') = SUM(A,SAM('NSLAB',A))/NSLABE;
QF0('SLAB',A) = SAM('SLAB',A)/PF0('SLAB');
QF0('NSLAB',A) = SAM('NSLAB',A)/PF0('NSLAB');
* Capital price set to unity initially
PF0('CAP') = 1;
QF0('CAP',ANO) = SAM('CAP',ANO);
QF0('CAP',AO) = SAM('CAP',AO) - PROFA0(AO);
* Factor endowments
QFS(F) = SUM(A, QF0(F,A));
PARAMETERS costgap(A);
* costgap is used to check consistency in calibration:
* costgap = (factor cost) - (adjusted SAM value) = 0
* checking the consistency of the calibration
costgap(A) = SUM(F, PF0(F)*FPD0(F,A)*QF0(F,A)) - FCSTA0(A);
DISPLAY PF0, FPD0, QFS, QF0, QFU0, costgap;
*$ONTEXT
* elasticity coefficients in the activity prod. fn. using the FOC, for Sau
  di labor
alpha('SLAB',A) = SAM('SLAB',A)/FCSTA0(A);
* elasticity coefficients in the activity prod. fn. using the FOC, for non
  - Saudi labor
alpha('NSLAB',A) = SAM('NSLAB',A)/FCSTA0(A);
* elasticity coefficients in the activity prod. fn. using the FOC, for cap
  ital
alpha('CAP',ANO) = SAM('CAP',ANO)/FCSTA0(ANO);
alpha('CAP',AO) = (SAM('CAP',AO) - PROFA0(AO))/FCSTA0(AO);
* shift coefficients in the activity prod. fn.
ad(A) = QA0(A) / PROD(F, QF0(F,A)**alpha(F,A));
DISPLAY alpha, ad;
* Calculating the value added price in two ways to check
PARAMETER PVA01(A), AVMATCSTA0(A), MCSTA01(A), PA01;
PVA01(A) = FCSTA0(A)/QA0(A);
* this is by substituting FOC into the Prod Fn
PVA0(A) = PROD(F, ((FPD0(F,A)*PF0(F)/alpha(F,A))**alpha(F,A)) )/ad(A);
```

```
IO coeff: unit intermediate input requirement by activity a by commodity c
 ir(C,A) = SAM(C,A)/QA0(A);
* Average cost
 AVMATCSTA0(A) = SUM(C,ir(C,A));
* Material Input Cost from an alternative
 MCSTA01(A) = SUM(C,ir(C,A)*QA0(A));
*Checking the consistency of setting PA0=1
 PA01(ANO) = PVA0(ANO) + AVMATCSTA0(ANO) + ACTAX(ANO)/QA0(ANO);
 PA01(AO) = PVA0(AO) + AVMATCSTA0(AO) + ACTAX(AO)/QA0(AO) +
PROFA0(AO)/QA0(
     AO);
DISPLAY PVA0, PVA01, MCSTA0, MCSTA01, AVMATCSTA0, PA0, PA01;
* tariff rate
 tm(CM) = SAM('IMPTAX',CM)/SAM('ROW',CM);
 PM0(CM) = 1;
 PWM0(CM) = PM0(CM) / ( (1 + tm(CM))*EXR0);
 QM0(CM) = (SAM('IMPTAX',CM)+SAM('ROW',CM))/PM0(CM);
PARAMETER MTAX1, MTAX2;
 MTAX1 = SUM( CE, tm(CE)*EXR0*PWM0(CE)*QM0(CE) );
 MTAX2 = SAM('IMPTAX','TOTAL');
 DISPLAY MTAX1, MTAX2;
* export tax or subsidy rates
 * BUT there is no export tax or subsidy in SAM!
 te(CE) = 0;
 PE0(CE) = 1;
 PWE0(CE) = PE0(CE)/((1-te(CE))*EXR0);
 QE0(CE) = SAM(CE,'ROW')/PE0(CE);
*domestic non-oil output
 PD0(CNO) = 1;
 QD0(CNO)= (SUM(A, SAM(A,CNO)) - SAM(CNO,'ROW'))/PD0(CNO);
DISPLAY PE0, PWE0, QE0, PD0, QD0, PX0, QX0, PM0, PWM0, QM0, tm;
* PRODUCTION, AGGREGATION AND TRANSFORMATION ----------------
 * elasticities of substitution for aggregation & tranformation
* from the literature (Association of International Life Office)
 * there is no salse tax in Saudi Arabia
 tq(CNO)=0;
 tqadj0=1;
 *after tax sales price
 PQ0(CNO) = (1 + tq(CNO))*PD0(CNO);
 QQ0(CNO) = (SAM('TOTAL',CNO) - SAM(CNO,'ROW'))/PQ0(CNO);
PQ0(CO)=PD0(CO);
 QQ0(CO)=QD0(CO);
DISPLAY PQ0, QQ0;
PARAMETERS
 sigmaq(C) elasticities of substitution for CES aggregation
 sigmax(C) elasticities of substitution for CES tranformation
* THE FOLLOWING ARE FROM DI SANTIS'
TABLE EOS(*,C)
         AGRI-C  CRDO-C  REFI-C  MANF-C  UTIL-C  CONS-C  TRDS-C  NTRDS-C
 eq      2.20    2.80    2.80    2.80    1.90    1.90    1.90    1.90
 ex      1.50    1.50    1.50    1.50    1.50    1.50    1.50    1.50
sigmaq(C) = EOS('eq',C);
 sigmax(C) = EOS('ex',C);
* the implied exponent coefficients in the CES functions:
 rhoq(C) = 1/sigmaq(C)-1;
```

```
rhox(C) = 1/sigmax(C)+1;
* share ceoff in the CES transformation equation
deltax(C)$CE(C) = 1/( 1 + ( (PD0(C)/PE0(C)) * ((QE0(C)/QD0(C))**(rhox(C)-1))));
* share ceoff in the CES aggregation equation
deltaq(C)$CM(C) = 1/( 1 + ( (PD0(C)/PM0(C)) * ((QD0(C)/QM0(C))**(rhoq(C)+1
))));
* shift ceoff in the CES transformation equation
ax(C)$CE(C) = QX0(C)/( deltax(C)*QE0(C)**(rhox(C))
            + (1-deltax(C))*QD0(C)**(rhox(C)) )**(1/rhox(C));
* shift ceoff in the CES aggregation equation
aq(C)$CM(C) = QQ0(C)/( deltaq(C)*QM0(C)**(-rhoq(C))
            + (1-deltaq(C))*QD0(C)**(-rhoq(C)) )**(-1/rhoq(C));
DISPLAY rhoq, rhox, deltax, ax, deltaq, aq;
= = === =INVESTMENT, CONSUMPTION, INCOME, GOV ACC. BOP, etc =
*$ontext
* use by activity a of commodity c as intermediate input
QINT0(C,A)= SAM(C,A)/PQ0(C);
*investment adjustment is initially =1 (no adjustment)
IADJ0 = 1;
* INV = the relevant SAM rows in the S-I column (properly deflated)
inv(C) = SAM(C,'S-I')/PQ0(C);
* QINV = INV initially as IADJ0 = 1
QINV0(C) = INV(C);
QINV0(C)  = SAM(C,'S-I')/PQ0(C);
DISPLAY QINT0, QINV0, inv, IADJ0;
*$offtext
* householhd consumption, utility, CPI, etc.
* CONSUMPTION
QH0(C,H) = SAM(C,H)/PQ0(C);
* TOTAL CONSUMPTION EXPENDITURE
EH0(H) = SUM(C, PQ0(C)*QH0(C,H) );
* CONSUMTION SHARES
beta(C,H) = PQ0(C)*QH0(C,H)/EH0(H);
* consumer price index FOR EACH H
CPIH0(H) = PROD(C, PQ0(C)**beta(C,H) );
* UTILTY
UTILH0(H) = PROD(C, (QH0(C,H)/beta(C,H))**beta(C,H) );
* WEIGHTS IN CPI
MU0(H) = EH0(H)/ SUM(HAL, EH0(HAL) );
*consumer price index
CPI = SUM(H, MU0(H)*CPIH0(H) );
DISPLAY QH0, EH0, beta, UTILH0, MU0, CPIH0, CPI;
* TRANSFERS
TR0(H,'GOV')=SAM(H,'GOV')/CPI;
TR0(H,'ROW')=SAM(H,'ROW')/EXR0;
TR0('GOV',H) = SAM('INDTAX',H);
TR0('ROW',H)=SAM('ROW',H);
TR0('ROW','GOV')=SAM('ROW','GOV');
TR0('GOV','ROW')=SAM('GOV','ROW')/EXR0;
* Household income share from factor incomes
*shry(H,F) = SAM(H,F)/SAM('TOTAL', F);
shry(H,F) = SAM(H,F)/SUM(HAL,SAM(HAL, F));
* household factor income
YF0(H,F) = shry(H,F)*SUM(A,
        (PF0(F)*FPD0(F,A)*QF0(F,A))$LAB(F)
```

```
       + (PF0(F)*FPD0(F,A)*QF0(F,A))$(CAPT(F) AND ANO(A)) );
YF0('GOV','CAP') =
 SUM(AO, (PF0('CAP')*FPD0('CAP',AO)*QF0('CAP',AO) + PROFA0(AO)) );
PARAMETER YF01(I,F);
YF01(I,F) = SAM(I,F);
* household LABOUR income
YLABH0(H) = SUM(LAB,YF0(H,LAB));
* household total gross income
YH0(H) = SUM(F,YF0(H,F))+ EXR0*TR0(H,'ROW')+ CPI*TR0(H,'GOV');
PARAMETER YH01(H);
YH01(H)= SAM('TOTAL',H) - SAM(H,H);
* Household's tansfer to GOV consists of pension & other payments
tp('SHH')=0.09;
tp('NSHH')=0;
OTR0('GOV',H)= TR0('GOV',H) - tp(H)*YLABH0(H);
* HOUSEHOLDS' DIRECT TAX (ALLOWED FOR SIMULATION)
ty(H) =0;
tyadj0=1;
DTAX0(H)=ty(H)*(YH0(H)- TR0('GOV',H));
* HOUSEHOLDS' DISPOSABLEINCOME
DIH0(H) = YH0(H) - DTAX0(H) - TR0('GOV',H);

mpt(H)=TR0('ROW',H)/DIH0(H);
DISPLAY mpt;
*household total savings and propensity to save (from disposable income)
SH0(H) = DIH0(H) - TR0('ROW',H) - EH0(H);
PARAMETER SH01(H);
SH01(H) = SAM('S-I',H);
MPS0(H) = SH0(H)/(DIH0(H)-TR0('ROW',H));
mpsin(H) = MPS0(H);
MPSADJ0 = 0;
= = = =  CHOSING WHETHER BOTH SAUDI & NON-SAUDI HH SAVE = = =
WE CAN CHOOSE WHICH HOUSEHOLDS' SAVING TO CHANGE TO INANCE
INVESTMENT WHEN SAVING IS INVESTMENT DRIVEN, 0= DO NOT CHANGE;
1=CHANGE
Table HSAVEDUM(*,H)
          SHH NSHH
SAVDUM     1    0
*SAVDUM    0    0
mpsdum(H) = HSAVEDUM('SAVDUM',H);
DISPLAY shry, YF0, YF01, YLABH0, YH0, YH01, TR0, OTR0, DTAX0,
       DIH0, SH0, SH01, MPS0, mpsin, mpsdum, MPSADJ0;
* government consumption of commodities
QG(C) = SAM(C,'GOV')/PQ0(C);
* TESTING THE GOODS MARKET EQUILIBRIUM
* This is the National Income Identity where imports & exports are included
* in the other items
PARAMETER GMED(C) "should be zero if correct";
GMED(C) = QQ0(C) - SUM(H,QH0(C,H)) - QG(C) - QINV0(C) - SUM(
A,QINT0(C,A) );
DISPLAY GMED;
* government budget surplus (revenue less expenditure, transfers, etc)
* we create this in different ways to run a check
sdo=0;
GBS0 = YF0('GOV','CAP') + TR0('GOV','ROW')*EXR0 + SUM( A , ACTAX(A) )
```

```
      + SUM( H, (tp(H)*YLABH0(H) + DTAX0(H) + OTR0('GOV',H) ) )
      + SUM( C, (tm(C)*EXR0*PWM0(C)*QM0(C))$CM(C) )
      + SUM( C, (tq(C)*PD0(C)*QD0(C))$CNO(C) )
      + SUM( C, (tq(C)*PM0(C)*QM0(C))$CM(C) )
      - (TR0('ROW','GOV') + SUM( H, CPI*TR0(H,'GOV') )
      + SUM( C, (te(C)*EXR0*PWE0(C)*QE0(C))$CE(C) )
      + SUM( C, (sdo*PD0(C)*QD0(C))$CO(C) )
      + SUM( C, PQ0(C)*QG(C) ) )
GR0 = YF0('GOV','CAP') + TR0('GOV','ROW')*EXR0 + SUM( A , ACTAX(A) )
      + SUM( H, (tp(H)*YLABH0(H) + DTAX0(H) + OTR0('GOV',H) ) )
      + SUM( C, (tm(C)*EXR0*PWM0(C)*QM0(C))$CM(C) )
      + SUM( C, (tq(C)*PD0(C)*QD0(C))$CNO(C) )
      + SUM( C, (tq(C)*PM0(C)*QM0(C))$CM(C) )
* this is straight form SAM
PARAMETER GBS01;
GBS01 = SAM('S-I','GOV');
DISPLAY GBS01, GBS0, GR0;
* Balance of payments (in foreign currency)
BOP0 = SUM( CM, PWM0(CM)*QM0(CM) )
     + SUM( I,  TR0('ROW',I)/EXR0 )
     - SUM( CE, PWE0(CE)*QE0(CE) ) - SUM(CO, PWE0(CO)*QE0(CO) )
     - SUM(I, TR0(I,'ROW') )
* Alternatively, we can just use the net inflows and outflows
PARAMETER BOP01;
BOP01 = SAM('S-I','ROW')/EXR0;
DISPLAY BOP0, BOP01;
* Walras Law requires WALR0 = 0
* if the model is correctly calibrated in general equilibrium
WALR0 = SUM(H, SH0(H)) + GBS0 + EXR0*BOP0 - SUM(C,PQ0(C)*QINV0(C));
DISPLAY WALR0;
*$ONTEXT
= = = = = = ==  = = = = = PREPARING TO SOLVE AND REPORT = = = = = = = =  =
WE SET UP A LOOP FOR SOLUTION IN WHICH:
THE 1ST ITEM GENERATES THE BASE SOLUTION, AND THE 2ND ITEM
GENERATES THE SOLUTION FOR A GIVEN SHOCK, AND SO ON
= = =SETS AND PARAMETERS FOR STORING RESULTS AND REPORTING THEM
= = = =
SETS

* SET OF VARIABLE SOLUTION VALUES TO BE DISPLAYED
REP "SET OF VARIABLES TO BE REPORTED: BASE, SIMULATION,
%CHANGE"
 /
   BASE        "BASE SOLUTION = calibrated values"
   SHOCKED     "SHOCKED SOLUTION"
   PCHANGE     "% change in the value of the variable "
*   PCHANGE = 100*(SHOCKED - BASE)/BASE
**  NOTE THAT THIS CAN ONLY BE GENERATED IF 'BASE' IS POSITIVE.
* CASES FOR WHICH A SOLUTION IS TO BE OBTAINED IN THE LOOP
SOLU(REP) "SET OF SOLUTIONS: BASE, SIMULATION"
 /
   BASE        "base simulation = calibrated values"
   SHOCKED     "SHOCKED SOLUTION"
* SET OF GDP RELATED VARIABLES TO BE GENERATED FROM THE
SOLUTIONS
```

```
ACGDP "All GDP items"
 /
   GDPFC       "GDP at factor prices"
   GDPGAP      "gap bt alternative calculations for GDP at market prices"
   GDPMP1      "GDP at market prices (from spending side)"
   GDPMP2      "GDP at market prices (from income side)"
   PRVCON      "private consumption"
   INVEST      "investment"
   GOVCON      "government consumption"
   EXP         "exports of goods and services"
   IMP         "imports of goods and services"
   NITAX       "net indirect taxes"
 /
ACGDP1(ACGDP) "components of GDP at market prices"
 /
   PRVCON          "private consumption"
   INVEST          "investment"
   GOVCON          "government consumption"
   EXP             "exports of goods and services"
   IMP             "imports of goods and services"
 /
* DEFINING THE EXOGENOUS VALUES TO BE USED IN SOLUTION FOR BASE & SHOCKED CASES
PARAMETERS
sdosim(REP)       "DOMESTIC OIL PRICE SUBSIDY "
QEODUMSIM(REP)    "SAUDI OIL EXPORT SUPPLY SHOCK"
ROWODISIM(CO,REP)   "WORLD OIL DEMAND BASE, ROWODI (just for an experiment ) "
tmsim(CM,REP)      "Tariff rate for  commodities(just for experiment) "
tqsim(C,REP)       "sales tax rate"
tysim(H,REP)       "income tax rate"
* NOTE: IN ADDITION TO THE ABOVE, YOU CAN USE tq, to, te, etc IN YOUR SIMULATIONS
= = = = = =  == = = = = SETTING THE BENCH & SHOCKED ASES = = = = = = == =
sdosim('BASE') = 0;
sdosim('SHOCKED') = 0;
QEODUMSIM('BASE') = 0;
QEODUMSIM('SHOCKED') = 0;
ROWODISIM(CO,'BASE') = ROWODI(CO);
ROWODISIM(CO,'SHOCKED') = 1.05*ROWODI(CO);
tmsim(CM,'BASE')= tm(CM);
tmsim(CM,'SHOCKED') = 0;
tqsim(C,'BASE')= tq(C);
tqsim(C,'SHOCKED') = 1;
tysim(H,'BASE')= ty(H);
tysim(H,'SHOCKED') = 1;
*DISPLAY ROWODISIM, tmsim, QEODUMSIM, sdosim;
* THESE STORE THE VALUES OF THE VARIABLES TO BE REPORTED OR BASE & SHOCKED CASES:
```

```
PARAMETERS
AVCSTREP(CO,REP)    "average cost of producing comodity c    "
BOPREP(REP)         "balance of payment (foreign savings) in foreign currecy)"
CPIHREP(H,REP)
DIHREP(H,REP)
DTAXREP(H,REP)
EHREP(H,REP)
EPSIREP(CO,REP)  "price elasticity of demand for Saudi oil by the ROW"
EXRREP(REP)   "exchange rate (dom. currency per unit of for. currency)  "
FCSTAREP(A,REP)     "factor input cost of activity a "
FPDREP(F,A,REP)     "wage distortion factor for factor f in activity a          "
GBSREP(REP)         "government budget surplus (or deficit)     "
GRREP(REP)
tqadjREP(REP)
tyadjREP(REP)
GDPREP(*,REP)       "nominal GDP data: National Income Accounts          "
IADJREP(REP)        "investment adjustment factor          "
MCSTAREP(A,REP)     "material input cost of avtivity a          "
MPSADJREP(REP)
MPSREP(H,REP)"marginal (and average) propensity to save for household h"
OTRREP(I,IAL,REP)   "other transfers          "
PAREP(A,REP)        "price of activity a          "
PDREP(C,REP)        "domestic price of domestic output c          "
PEREP(C,REP)        "export price for c (domestic currency)          "
PFAREP(F,A,REP)     "factor price of f adjusted for distortion          "
PFREP(F,REP)        "average price of factor f          "
PMREP(C,REP)        "import price for c (domestic currency)          "
PQREP(C,REP)        "composite commodity price for c          "
PROFAREP(AO,REP)    "profit of activity a in A space          "
PROFCREP(CO,REP)    "profits of activity a in C space          "
PVAREP(A,REP)       "value-added price for activity a          "
PWEREP(C,REP)       "export (world) price for c (foreign currency)   "
PWMREP(C,REP)       "import (world) price for c (foreign currency)  "
PXREP(C,REP)        "producer price for commodity c   "
QAREP(A,REP)    "level of activity a = qt of output produced by activity a"
QDREP(C,REP)        "quantity sold domestically of domestic output c      "
QEREP(C,REP)        "quantity of exports for commodity c     "
QFREP(F,A,REP)      "quantity demanded of factor f from activity a       "
QFUREP(F,REP)       "excess sup. of factor f (e.g. unemployment)        "
QHREP(C,H,REP)    "quantity consumed of commodity c by households   "
QINTREP(C,A,REP) "qnty of commodity c as intermediate input to activity a "
QINVREP(C,REP)      "quantity of investment demand for commodity c      "
QMREP(C,REP)        "quantity of imports of commodity c       "
QQREP(C,REP)  "quantity of goods supplied domestically (composite supply)"
QXREP(C,REP)        "quantity of domestic output of commodity c       "
ROWODREP(CO,REP)    "total demand for oil by the ROW          "
ROWOSREP(CO,REP)    "total supply of oil by the ROW      "
SHREP(H,REP)
TCSTAREP(A,REP)     "total cost of activity a     "
TRREP(I,IAL,REP)    "transfers     "
UTILHREP(H,REP)
WALRREP(REP)        "dummy variable (zero at equilibrium)        "
YFREP(I,F,REP)      "gross income of households from factor f          "
YHREP(H,REP)        "total gross income of household          "
YLABHREP(H,REP)
```

= = = = = = = == == = = *CHOOSING THE CLOSURE TYPE* = = = = === == = = ==

CHANGE THESE VALUES TO CHOOSE THE CLOSURE TYPE

```
* CHANGE THESE VALUES TO CHOOSE THE CLOSURE TYPE
* EXRCLOS = 1, FS is fixed & a flexible exchange rate clears the BOP
* EXRCLOS = 2, The exchange rate is fixed & a flexible BOP is allowed
SCALAR EXRCLOS "exchange rate regime closure" /2/;
* SICLOS=1, Investment-driven savings, MPS is flexible.
* SICLOS=2, Savings-driven investment, INVEST is flexible.
SCALAR SICLOS "savings-investment closure" /1/;
* CAPCLOS = 1, capital is mobile and fully employed
* CAPCLOS = 2, capital is activity-specific and fully employed
SCALAR CAPCLOS "closure for capital market" /2/;
* SLABCLOS = 1, SAUDI labour is mobile and wage is flexible, no unemployed
* SLABCLOS = 2, SAUDI labour is mobile and wage is fixed, unemployed  adjusts
SCALAR SLABCLOS "closure for labour market" /1/;
* NSLABCLOS = 1, NON-SAUDI labour is mobile and wage is flexible, no unemployed
* NSLABCLOS = 2, NON-SAUDI labour is mobile and wage is fixed, unemployed adjusts
* NON-SAUDI labour is immobile and fullyemployed
* Its wage adjusts to clear the market
```

= = = = = = *SOLVING FOR THE BENCH & SHOCKED CASES* = = = = == = == ==

RECALL THAT WE SET UP A LOOP FOR SOLUTION IN WHICH:
THE 1ST ITEM GENERATES THE BASE SOLUTION, AND THE 2ND ITEM GENERATES THE SOLUTION FOR A GIVEN SHOCK, AND SO ON
WE ALSO DECIDE WHAT WE WANT TO REPORT AND GENERATE IT
THE LOOP BELOW RUNS OVER THE SET REP ={BASE, PWEINCR}, AND FOR EACH SOLUTION STORES THE VALUES OF THE VARIABLES AS REQUIRED

= = = = *SETTING THE INITIAL VALUES OF THE EXOGENOUS VARIABLES* = = =

LOOP(SOLU),

= = = = = = = = == = = = = = = = *CLOSURE RULES* = = = = = = == = = = = = = = = = ==

FIXING THE WORLD PRICES OF IMPORTS AND EXPORTS
IMPORT PRICES AND ALL NON-OIL EXPORT PRICES ARE FIXED BY THE WORLD PRICE

```
PWM.FX(CM) = PWM0(CM);
PWE.FX(CE) = PWE0(CE);
* FIXING THE TRANSFERS
OTR.FX(I,IAL) = OTR0(I,IAL);
TR.FX('GOV',IAL) = TR0('GOV',IAL);
TR.FX('ROW','GOV') = TR0('ROW','GOV');
TR.FX(H,'GOV') = TR0(H,'GOV');
TR.FX(H,'ROW') = TR0(H,'ROW');
```

= = = = = = = = = = = = = = *EXCHANGE RATE POLICY* = = = = = = = = = = = = = =

EXCHANGE RATE CAN BE FIXED OR FLEXIBLE

```
* Define a dummy  EXRCLOS = 1 or 2 so that
* if EXRCLOS = 1, exchange rate is flexible ensures BOP=0
* if EXRCLOS = 2, BOP is flexible and EXR is fixed.
IF(EXRCLOS EQ 1,
* BOP is fixed.
```

```
* A flexible exchange rate clears the current account
BOP.FX = BOP0;
EXR.LO = -INF;
EXR.UP = +INF;
EXR.L  = EXR0;
IF(EXRCLOS EQ 2,
* The exchange rate is fixed.
* A flexible FS is allowed
EXR.FX = EXR0;
BOP.LO = -INF;
BOP.UP = +INF;
BOP.L  = BOP0;
```

= = = = = = = = = = = = *SAVINGS-INVESTMENT BEHAVIOUR*= = = = = = = = = = = =

INVESTMENT CAN BE SAVING-DRIVEN OR EXOGENOUS

```
* Define a dummy SICLOS = 1 or 2 so that
* if SICLOS = 1, investment is exogenous and savings is investment-driven
* if SICLOS = 2, saving is exogenous and investment is savings-driven
IF(SICLOS EQ 1,
* Investment-driven savings,
* MPS is flexible, permitting savings value to adjust
IADJ.FX = IADJ0;
MPSADJ.LO = -INF;
MPSADJ.UP = +INF;
MPSADJ.L = MPSADJ0;
IF(SICLOS EQ 2,
* Savings-driven investment
* IADJ is flexible, permitting investment to adjust
MPSADJ.FX = MPSADJ0;
IADJ.LO = -INF;
IADJ.UP = +INF;
IADJ.L = IADJ0;
```

= = = = = = = = = = = = = = = = *FACTOR MARKETS* == = = = = = = = = = = == = = = =

CAPITAL MARKETS

```
* Define a dummy CAPCLOS = 1 or 2 so that
* if CAPCLOS = 1, capital is mobile and fully employed
* if CAPCLOS = 2, capital is activity-specific and fully employed
IF(CAPCLOS EQ 1,
* Capital is fully mobile and fully employed
* FPD('CAP',A) is fixed
* PF('CAP') adjusts to clear the market
* QFU('CAP')=0
FPD.FX('CAP',A) = FPD0('CAP',A);
PF.LO('CAP') = -INF;
PF.UP('CAP') = +INF;
PF.L('CAP') = PF0('CAP');
QF.LO('CAP',A) = -INF;
QF.UP('CAP',A) = +INF;
QF.L('CAP',A) = QF0('CAP',A);
QFU.FX('CAP')=QFU0('CAP');
IF(CAPCLOS EQ 2,
* Capital is activity-specific and fully employed in each activity
* QF('CAP',A) is exogenous and FPD('CAP',A)*PF('CAP') adjusts to ensure
* each activity capital market clears. Thus,
* PF('CAP') is fixed,
```

```
* FPD('CAP',A) adjusts to clear the market
* but there nay be unemployed capital in the aggregate,
* so QFU('CAP') is endogenous
FPD.LO('CAP',A) = -INF;
FPD.UP('CAP',A) = +INF;
FPD.L('CAP',A) = FPD0('CAP',A);
PF.FX('CAP') = PF0('CAP');
QF.FX('CAP',A) = QF0('CAP',A);
QFU.LO('CAP') = -INF;
QFU.UP('CAP') = +INF;
QFU.L('CAP')=QFU0('CAP');
```

= = = = = = = = = = == = = = == = *LABOUR MARKETS* = = = = = = = = = = = = = = = =

EACH ACTIVITY USES TWO TYPES OF LABOUR: LAB = {SLAB, NSLAB}EACH TYPE IS FULLY MOBILE AND CAN BE EMPLOYED OR UNEMPLOYED

= = = = = = === = = = = = = = = = *TYPE SLAB* = = = = = = = = = = = = = = = = = =

```
*Define a dummy SLABCLOS = 1 or 2 so that
*IF SLABCLOS = 1, labour is mobile and wage is flexible, no unemployed
*IF SLABCLOS = 2, labour is mobile and wage is fixed, unemployed adjusts
IF(SLABCLOS EQ 1,
* there is no unemployed labour, QFU('SLAB')=0
* Labor is fully mobile, a unique wage clears the labour market:
* FPD('SLAB',A) is fixed,
* PF('SLAB') adjusts to clear the market
FPD.FX('SLAB',A) = FPD0('SLAB',A);
PF.LO('SLAB') = -INF;
PF.UP('SLAB') = +INF;
PF.L('SLAB') = PF0('SLAB');
QF.LO('SLAB',A) = -INF;
QF.UP('SLAB',A) = +INF;
QF.L('SLAB',A) = QF0('SLAB',A);
QFU.FX('SLAB') = QFU0('SLAB');
IF(SLABCLOS EQ 2,
* labour is mobile
* FPD('SLAB',A)*PF('SLAB') is fixed.
* there is unemployed labour, QFU('SLAB') adjusts to clear the market
FPD.FX('SLAB',A) = FPD0('SLAB',A);
PF.FX('SLAB') = PF0('SLAB');
QF.LO('SLAB',A) = -INF;
QF.UP('SLAB',A) = +INF;
QF.L('SLAB',A) = QF0('SLAB',A);
QFU.LO('SLAB') = -INF;
QFU.UP('SLAB') = +INF;
QFU.L('SLAB')=QFU0('SLAB');
*$ontext
```

= = = = = = = = = = = == = = = = = *TYPE NSLAB* = = = = = = = = = = = = = = = = = = =

```
* This labour is immobile and fully employed;
* Wage is flexible to clear the market
* there is may be unemployed labour,so  QFU('NSLAB') is endogenous
* FPD('NSLAB',A) adjusts to clear the market, and PF('NSLAB') is fixed
PF.FX('NSLAB') = PF0('NSLAB');
FPD.LO('NSLAB',A) = -INF;
```

1418 FPD.UP('NSLAB',A) = +INF;
1419 FPD.L('NSLAB',A) = FPD0('NSLAB',A);
1420 QFU.LO('NSLAB') = -INF;
1421 QFU.UP('NSLAB') = +INF;
1422 QFU.L('NSLAB') = QFU0('NSLAB');
1423 QF.FX('NSLAB',A) = QF0('NSLAB',A);

IF(SLABCLOS EQ 1,
there is no unemployed labour, QFU('SLAB')=0
Labor is fully mobile, a unique wage clears the labour market:
FPD('SLAB',A) is fixed,
PF('SLAB') adjusts to clear the market
FPD.FX('NSLAB',A) = FPD0('NSLAB',A);
PF.LO('NSLAB') = -INF;
PF.UP('NSLAB') = +INF;
PF.L('NSLAB') = PF0('NSLAB');
QF.LO('NSLAB',A) = -INF;
QF.UP('NSLAB',A) = +INF;
QF.L('NSLAB',A) = QF0('NSLAB',A);
QFU.FX('NSLAB') = QFU0('NSLAB');

==============*OIL MARKET ANDQUOTA*==============

The determination of price of oil depends on the choice of OILCLOS = 1 or 2
defined and set just before equation descriptions above

1447 IF(OILCLOS EQ 1,
There is no quota in operation oil price is determined by the country's monopoly behavior m arkup equation EQ22 is activated and both PWE and QE are endogenous:
1451 QE.L(CO) = QE0(CO);
1452 QE.LO(CO) = -INF;
1453 QE.UP(CO) = +INF;
1454 PWE.L(CO) = PWE0(CO);
1455 PWE.LO(CO) = -INF;
1456 PWE.UP(CO) = +INF;

*WE DO NOT MODEL THE QUOTA OPTION HERE.
IF(OILCLOS EQ 2,
There is quota in operation oil price is determined by the world oil market
Markup equation EQ0220 is switched off, QE is kept constant at the initial level (assumed to be fixed by Quota), and only PWE is endogenous:
1466 *QE.FX(CO) = QE0(CO);
= == = = = = = = = = = = = END OF CLOSURE SETTING = = = = == == = = = = =

Fixing all other ENDOGENOUS variables for which there is no choice
1472 AVCST.L(CO) = AVCST0(CO);
1473 CPIH.L(H) = CPIH0(H);
1474 DIH.L(H) = DIH0(H);
1475 DTAX.L(H) = DTAX0(H);
1476 EH.L(H) = EH0(H);
1477 EPSI.L(CO) = EPSI0(CO);
1478 FCSTA.L(A) = FCSTA0(A);
1479 GBS.L = GBS0;
1481 MU.L(H) = MU0(H);
1483 MCSTA.L(A) = MCSTA0(A);
1484 MPS.L(H) = MPS0(H);
1485 PA.L(A) = PA0(A);

```
PD.L(C) =      PD0(C);
PE.L(CE) =     PE0(CE);
PE.L(CO) =     PE0(CO);
PM.L(CM) =     PM0(CM);
PQ.L(C) =      PQ0(C);
PROFA.L(AO) =  PROFA0(AO);
PROFC.L(CO) =  PROFC0(CO);
PVA.L(A) =     PVA0(A);
PX.L(C) =      PX0(C);
QA.L(A) =      QA0(A);
QD.L(C) =      QD0(C);
QE.L(CE) =     QE0(CE);
QH.L(C, H) =   QH0(C, H);
QINT.L(C, A) =  QINT0(C, A);
QINV.L(C) =    QINV0(C);
QM.L(CM) =      QM0(CM);
QQ.L(C) =      QQ0(C);
QX.L(C) =      QX0(C);
ROWOD.L(CO) =  ROWOD0(CO);
ROWOS.L(CO) =  ROWOS0(CO);
SH.L(H) =      SH0(H);
TCSTA.L(A) =   TCSTA0(A);
TR.L('ROW',H) = TR0('ROW',H);
UTILH.L(H) =   UTILH0(H);
WALR.L =       WALR0;
YF.L(H,F) =    YF0(H,F);
YF.L('GOV','CAP') =    YF0('GOV','CAP');
YH.L(H) =      YH0(H);
YLABH.L(H) =   YLABH0(H);
```

= = = = = = = = = = = = = *CHOOSING THE SHOCK*= = = = = = == = = = = = = = = =
CHOOSING THE VALUE OF THE VARIABLE THAT IS SHOCKED

```
sdo = sdosim(SOLU);
QEODUM = QEODUMSIM(SOLU);
ROWODI(CO) = ROWODISIM(CO,SOLU);
*tm(CM) = tmsim(CM,SOLU);
*tq(C) = tqsim(C,SOLU) ;
*ty(H) =  tysim(H,SOLU) ;
* FIXING THE ENDOGENOUS & EXOGOUNOUS VARIABLES
GR.L =        GR0;
tqadj.FX =    tqadj0;
tyadj.FX =    tyadj0;
```

= = = = = = = = = = = = = = *SOLVING THE MODEL* = == = = = = = = = = = = = = = =

```
OPTION MCP=PATH;
SOLVE SAUDIV1 USING MCP;
```

= = = = = = = = = = = = = = *STORING THE SOLUTION* = = = = = = = = = = = = = == ==
ABDULLAH: FROM HERE ON YOU WILL HAVE TO CONSTRUCT WHAT YOU WANT TO CREAT E, STORE AND DISPLAY ERRORS.

```
AVCSTREP(CO, SOLU) =           AVCST.L(CO);
BOPREP(SOLU) =                 BOP.L      ;
CPIHREP(H, SOLU) =             CPIH.L(H)  ;
```

```
DIHREP(H, SOLU) =             DIH.L(H)   ;
DTAXREP(H, SOLU) =            DTAX.L(H)  ;
EHREP(H, SOLU) =              EH.L(H)    ;
EPSIREP(CO, SOLU) =           EPSI.L(CO) ;
EXRREP(SOLU) =                EXR.L      ;
FCSTAREP(A, SOLU) =           FCSTA.L(A) ;
FPDREP(F,A, SOLU) =           FPD.L(F,A) ;
GBSREP(SOLU) =                GBS.L      ;
GRREP(SOLU) =                 GR.L       ;
tqadjREP(SOLU) =              tqadj.L    ;
tyadjREP(SOLU) =              tyadj.L    ;
IADJREP(SOLU) =               IADJ.L     ;
MCSTAREP(A, SOLU) =           MCSTA.L(A) ;
MPSREP(H, SOLU) =             MPS.L(H)   ;
MPSADJREP(SOLU) =             MPSADJ.L   ;
PAREP(A, SOLU) =              PA.L(A)    ;
PDREP(C, SOLU) =              PD.L(C)    ;
PEREP(C, SOLU) =              PE.L(C)    ;
PFAREP(F,A,SOLU) = PF.L(F)*FPD.L(F,A)     ;
PFREP(F, SOLU) =              PF.L(F)    ;
PMREP(C, SOLU) =              PM.L(C)    ;
PQREP(C, SOLU) =              PQ.L(C)    ;
PROFAREP(AO, SOLU) =          PROFA.L(AO);
PROFCREP(CO, SOLU) =          PROFC.L(CO);
PVAREP(A, SOLU) =             PVA.L(A)   ;
PWEREP(C, SOLU) =             PWE.L(C)   ;
PWMREP(C, SOLU) =             PWM.L(C)   ;
PXREP(C, SOLU) =              PX.L(C)    ;
QAREP(A, SOLU) =              QA.L(A)    ;
QDREP(C, SOLU) =              QD.L(C)    ;
QEREP(C, SOLU) =              QE.L(C)    ;
QFREP(F,A, SOLU) =            QF.L(F,A)  ;
QFUREP(F, SOLU) =             QFU.L(F)   ;
QHREP(C,H, SOLU) =            QH.L(C,H)  ;
QINTREP(C,A, SOLU) =          QINT.L(C,A);
QINVREP(C, SOLU) =            QINV.L(C)  ;
QMREP(C, SOLU) =              QM.L(C)    ;
QQREP(C, SOLU) =              QQ.L(C)    ;
QXREP(C, SOLU) =              QX.L(C)    ;
ROWODREP(CO, SOLU) =          ROWOD.L(CO);
ROWOSREP(CO, SOLU) =          ROWOS.L(CO);
SHREP(H, SOLU) =              SH.L(H)    ;
TCSTAREP(A, SOLU) =           TCSTA.L(A) ;
TRREP('ROW',H,SOLU) =         TR.L('ROW',H);
UTILHREP(H, SOLU) =           UTILH.L(H) ;
WALRREP(SOLU) =               WALR.L     ;
YFREP(I,F, SOLU) =            YF.L(I,F)  ;
YHREP(H, SOLU) =              YH.L(H)    ;
YLABHREP(H, SOLU) =           YLABH.L(H) ;
* CREATING AND PROCESSING THE GDP data
* This is the equivalent of the National Income Table
GDPREP('PRVCON',SOLU) = SUM((C,H), PQ.L(C)*QH.L(C,H)) ;
GDPREP('GOVCON',SOLU) = SUM(C, PQ.L(C)*QG(C));
GDPREP('INVEST',SOLU) = SUM(C, PQ.L(C)*QINV.L(C));
GDPREP('EXP',SOLU)    = SUM(C, EXR.L*PWE.L(C)*QE.L(C));
```

```
GDPREP('IMP',SOLU)    = - SUM(C, EXR.L*PWM.L(C)*QM.L(C));
GDPREP('GDPFC',SOLU)  = SUM((F,A), PF.L(F)*FPD.L(F,A)*QF.L(F,A));
*GDPREP('NITAX',SOLU)  = SUM(C,
tq(C)*(PD.L(C)*QD.L(C)+(PM.L(C)*QM.L(C))$C M(C)))
*                      + SUM(C$CM(C), tm(C)*EXR.L*PWM.L(C)*QM.L(C))
*                     + SUM(C, IMPTAX(C))
*                     + SUM(A, ACTAX(A))
*                      + INDTAX
*                     - SUM( C$CE(C), te(C)*EXR.L*PWE.L(C)*QE.L(C));
* END OF LOOP
);
*Processing GDP data
* IMPORTANT: CHECK WITH JOHN DEWHURST IF THESE DEFINITIONS
ARE CORRECR
* WHEN PROFIT EXISTS
GDPREP('GDPMP1',SOLU) = SUM(ACGDP1, GDPREP(ACGDP1,SOLU));
GDPREP('GDPMP2',SOLU) = GDPREP('GDPFC',SOLU) +
GDPREP('NITAX',SOLU);
GDPREP('GDPGAP',SOLU) = GDPREP('GDPMP1',SOLU) -
GDPREP('GDPMP2',SOLU);
*Processing GDP data
* IMPORTANT: CHECK WITH JOHN DEWHURST IF THESE DEFINITIONS
ARE CORRECR
* WHEN PROFIT EXISTS
GDPREP('GDPMP1',SOLU) = SUM(ACGDP1, GDPREP(ACGDP1,SOLU));
GDPREP('GDPMP2',SOLU) = GDPREP('GDPFC',SOLU) +
GDPREP('NITAX',SOLU);
GDPREP('GDPGAP',SOLU) = GDPREP('GDPMP1',SOLU) -
GDPREP('GDPMP2',SOLU);

= = = = = = = = = =PROCESSING THE %CHANGE SERIES = = = = = = = = = = =

IMPORTANT: NEUTRALISE THE EXOGENISED VARIABLES
BY PUTTING A * AT THE BEGINNING OF THE LINE
BOPREP('PCHANGE')$(BOPREP('BASE')>0)  = 100*(BOPREP('SHOCKED')
- BOPREP('BASE'))
                       /BOPREP('BASE');

BOPREP('PCHANGE')$(BOPREP('BASE')<=0)
                     = (BOPREP('SHOCKED') - BOPREP('BASE'));

CPIHREP(H,'PCHANGE') = 100*(CPIHREP(H,'SHOCKED') -
CPIHREP(H,'BASE'))  /CPIHREP(H,'BASE');

FCSTAREP (A,'PCHANGE')$(FCSTAREP(A,'BASE')>0) = 100*(FCSTAREP
(A,'SHOCKED' )
                       - FCSTAREP (A,'BASE'))/FCSTAREP(A,'BASE');
FCSTAREP (A,'PCHANGE')$(FCSTAREP(A,'BASE')<=0) = (FCSTAREP
(A,'SHOCKED')
                       - FCSTAREP (A,'BASE'));

GRREP('PCHANGE')  = 100*(GRREP('SHOCKED') - GRREP('BASE'))
                       /GRREP('BASE');

GBSREP('PCHANGE')$(GBSREP('BASE')>0)
```

```
                   = 100*(GBSREP('SHOCKED') - GBSREP('BASE'))
                    /GBSREP('BASE');

GBSREP('PCHANGE')$(GBSREP('BASE')<0)
                   = 100*(GBSREP('SHOCKED') - GBSREP('BASE'))
                    /GBSREP('BASE');

IADJREP('PCHANGE') = 100*(IADJREP('SHOCKED') - IADJREP('BASE'))
                    /IADJREP('BASE');
MPSREP(H,'PCHANGE') = 100*(MPSREP(H,'SHOCKED') - MPSREP(H,'BASE'))
                    /MPSREP(H,'BASE');
PAREP(A,'PCHANGE')  = 100*(PAREP(A,'SHOCKED') - PAREP(A,'BASE'))
                    /PAREP(A,'BASE');
PDREP(C,'PCHANGE')  = 100*(PDREP(C,'SHOCKED') - PDREP(C,'BASE'))
                    /PDREP(C,'BASE');

PEREP(CE,'PCHANGE') = 100*(PEREP(CE,'SHOCKED') - PEREP(CE,'BASE'))
                    /PEREP(CE,'BASE');
PEREP(CO,'PCHANGE') = 100*(PEREP(CO,'SHOCKED') - PEREP(CO,'BASE'))
                    /PEREP(CO,'BASE');

PFREP(F,'PCHANGE')  = 100*(PFREP(F,'SHOCKED') - PFREP(F,'BASE'))
                    /PFREP(F,'BASE');
PFAREP(F,A,'PCHANGE') = 100*(PFAREP(F,A,'SHOCKED') -
PFAREP(F,A,'BASE'))
                    /PFAREP(F,A,'BASE');
PMREP(CM,'PCHANGE') = 100*(PMREP(CM,'SHOCKED') -
PMREP(CM,'BASE'))
                    /PMREP(CM,'BASE');
PQREP(C,'PCHANGE')  = 100*(PQREP(C,'SHOCKED') - PQREP(C,'BASE'))
                    /PQREP(C,'BASE');

PVAREP(A,'PCHANGE') = 100*(PVAREP(A,'SHOCKED') - PVAREP(A,'BASE'))
/PVAREP(A,'BASE');

PWEREP(CE,'PCHANGE') = 100*(PWEREP(CE,'SHOCKED') -
PWEREP(CE,'BASE'))  /PWEREP(CE,'BASE');

PXREP(C,'PCHANGE') = 100*(PXREP(C,'SHOCKED') - PXREP(C,'BASE'))
                    /PXREP(C,'BASE');

QAREP(A,'PCHANGE') = 100*(QAREP(A,'SHOCKED') - QAREP(A,'BASE'))
                    /QAREP(A,'BASE');

QDREP(C,'PCHANGE') = 100*(QDREP(C,'SHOCKED') - QDREP(C,'BASE'))
                    /QDREP(C,'BASE');
QEREP(CE,'PCHANGE') = 100*(QEREP(CE,'SHOCKED') - QEREP(CE,'BASE'))
                    /QEREP(CE,'BASE');
QEREP(CO,'PCHANGE') = 100*(QEREP(CO,'SHOCKED') - QEREP(CO,'BASE'))
                    /QEREP(CO,'BASE');

QFREP(F,A,'PCHANGE') = 100*(QFREP(F,A,'SHOCKED') - QFREP(F,A,'BASE'))
                    /QFREP(F,A,'BASE');

QFUREP(F,'PCHANGE')$(QFUREP(F,'BASE')>0)
```

```
                    = 100*(QFUREP(F,'SHOCKED') - QFUREP(F,'BASE'))
                       /QFUREP(F,'BASE');

QFUREP(F,'PCHANGE')$(QFUREP(F,'BASE')<=0)
                    =(QFUREP(F,'SHOCKED') - QFUREP(F,'BASE')) ;

QHREP(C,H,'PCHANGE')$(QHREP(C,H,'BASE')>0)
                      = 100*(QHREP(C,H,'SHOCKED') - QHREP(C,H,'BASE'))
                        /QHREP(C,H,'BASE');

QHREP(C,H,'PCHANGE')$(QHREP(C,H,'BASE')<=0)
                      =(QHREP(C,H,'SHOCKED') - QHREP(C,H,'BASE')) ;

QINVREP(C,'PCHANGE')$(QINVREP(C,'BASE')>0)
                      = 100*(QINVREP(C,'SHOCKED') - QINVREP(C,'BASE'))
                          /QINVREP(C,'BASE');

QINVREP(C,'PCHANGE')$(QINVREP(C,'BASE')<=0)
                      =(QINVREP(C,'SHOCKED') - QINVREP(C,'BASE'));

MCSTAREP(A,'PCHANGE')$(MCSTAREP(A,'BASE')>0)
                      = 100*(MCSTAREP(A,'SHOCKED') - MCSTAREP(A,'BASE'))
                        /MCSTAREP(A,'BASE');

MCSTAREP(A,'PCHANGE')$(MCSTAREP(A,'BASE')<=0)
                      = (MCSTAREP(A,'SHOCKED') - MCSTAREP(A,'BASE'));

AVCSTREP(CO,'PCHANGE')$( AVCSTREP(CO,'BASE')>0)
                      = 100*( AVCSTREP(CO,'SHOCKED') -  AVCSTREP(CO,'BASE '))
                        / AVCSTREP(CO,'BASE');
AVCSTREP(CO,'PCHANGE')$( AVCSTREP(CO,'BASE')<=0)
                      = (AVCSTREP(CO,'SHOCKED') -  AVCSTREP(CO,'BASE'));

TCSTAREP(A,'PCHANGE')$( TCSTAREP(A,'BASE')>0)
                      = 100*( TCSTAREP(A,'SHOCKED') - TCSTAREP(A,'BASE'))
                       /TCSTAREP(A,'BASE');

TCSTAREP(A,'PCHANGE')$(  TCSTAREP(A,'BASE')<=0)
                      = ( TCSTAREP(A,'SHOCKED') -   TCSTAREP(A,'BASE'));

QINVREP(C,'PCHANGE')$(QINVREP(C,'BASE')>0)
                      = 100*(QINVREP(C,'SHOCKED') - QINVREP(C,'BASE'))
                          /QINVREP(C,'BASE');

QINVREP(C,'PCHANGE')$(QINVREP(C,'BASE')<=0)
                      =(QINVREP(C,'SHOCKED') - QINVREP(C,'BASE'));

QMREP(CM,'PCHANGE') = 100*(QMREP(CM,'SHOCKED') -
QMREP(CM,'BASE'))/QMREP(CM,'BASE');

QQREP(C,'PCHANGE')  = 100*(QQREP(C,'SHOCKED') - QQREP(C,'BASE'))
/QQREP(C,'BASE');

QXREP(C,'PCHANGE')  = 100*(QXREP(C,'SHOCKED') - QXREP(C,'BASE'))
/QXREP(C,'BASE');
```

```
YFREP(I,F,'PCHANGE')$(YFREP(I,F,'BASE')>0)
               = 100*(YFREP(I,F,'SHOCKED') - YFREP(I,F,'BASE'))
                 /YFREP(I,F,'BASE');

YFREP(I,F,'PCHANGE')$(YFREP(I,F,'BASE')<=0)
               = (YFREP(I,F,'SHOCKED') - YFREP(I,F,'BASE'));

YHREP(H,'PCHANGE')$(YHREP(H,'BASE')>0)
         = 100*(YHREP(H,'SHOCKED') - YHREP(H,'BASE'))/YHREP(H,'BA
   SE');
YHREP(H,'PCHANGE')$(YHREP(H,'BASE')<=0)
              = (YHREP(H,'SHOCKED') - YHREP(H,'BASE'));

   GDPREP(ACGDP,'PCHANGE')$(GDPREP(ACGDP,'BASE')>0) =
100*(GDPREP(ACGDP,'SHOCKED')  - GDPREP(ACGDP,'BASE'))
/GDPREP(ACGDP,'BASE');

GDPREP(ACGDP,'PCHANGE')$(GDPREP(ACGDP,'BASE')<=0)
                   = (GDPREP(ACGDP,'SHOCKED')- GDPREP(ACGDP,'BASE'  ));

PEREP(CO,'PCHANGE') = 100*(PEREP(CO,'SHOCKED') - PEREP(CO,'BASE'))
/PEREP(CO,'BASE');

ROWODREP (CO,'PCHANGE')$(ROWODREP(CO,'BASE')>0) =
100*(ROWODREP(CO,'SHOCKED   ') -
ROWODREP(CO,'BASE'))/ROWODREP(CO,'BASE'  );

ROWODREP(CO,'PCHANGE')$(ROWODREP(CO,'BASE')<=0)
      =(ROWODREP(CO,'SHOCKED') - ROWODREP(CO,'BA SE'));

ROWOSREP(CO,'PCHANGE')$(ROWOSREP(CO,'BASE')>0)=
100*(ROWOSREP(CO,'SHOCKED' )   -
ROWOSREP(CO,'BASE'))/ROWOSREP(CO,'BASE');


ROWOSREP(CO,'PCHANGE')$(ROWOSREP(CO,'BASE')<=0)
     =(ROWOSREP(CO,'SHOCKED')- ROWOSREP(CO,'BA SE'));

PROFCREP(CO,'PCHANGE')$(PROFCREP(CO,'BASE')>0)=
100*(PROFCREP(CO,'SHOCKED' )
             - PROFCREP(CO,'BASE'))/PROFCREP(CO,'BASE'   );

PROFCREP(CO,'PCHANGE')$(PROFCREP(CO,'BASE')<=0)
          =(PROFCREP(CO,'SHOCKED')- PROFCREP(CO,'BASE'));

UTILHREP(H,'PCHANGE')  = 100*(UTILHREP(H,'SHOCKED') -
UTILHREP(H,'BASE'))
                  /UTILHREP(H,'BASE');

YLABHREP(H,'PCHANGE')  = 100*(YLABHREP(H,'SHOCKED') -
YLABHREP(H,'BASE'))
                  /YLABHREP(H,'BASE');

TRREP('ROW',H,'PCHANGE')  = 100*(TRREP('ROW',H,'SHOCKED') -
```

```
                    TRREP('ROW',H,'BASE'))/TRREP('ROW',H,'BASE');

SHREP(H,'PCHANGE')  = 100*(SHREP(H,'SHOCKED') - SHREP(H,'BASE')) /SHREP(H,'BASE');

MPSADJREP  ('PCHANGE')$(MPSADJREP('BASE')>0) = 100*(MPSADJREP ('SHOCKED')
                    - MPSADJREP ('BASE'))/MPSADJREP ('BASE');
MPSADJREP ('PCHANGE')$(MPSADJREP('BASE')<=0) = (MPSADJREP ('SHOCKED')
                    - MPSADJREP ('BASE'));
EHREP(H,'PCHANGE')  = 100*(EHREP(H,'SHOCKED') - EHREP(H,'BASE'))
                    /EHREP(H,'BASE');

DIHREP(H,'PCHANGE')  = 100*(DIHREP(H,'SHOCKED') - DIHREP(H,'BASE')) /DIHREP(H,'BASE');

DTAXREP (H,'PCHANGE')$(DTAXREP(H,'BASE')>0) = 100*(DTAXREP(H,'SHOCKED')
                    - DTAXREP(H,'BASE'))/DTAXREP(H,'BASE');

DTAXREP (H,'PCHANGE')$(DTAXREP(H,'BASE')<=0) = (DTAXREP(H,'SHOCKED')
                    - DTAXREP(H,'BASE'));

*Welfare of household H
*EV a CV
 PARAMETERS
EV(H)       "Equivalent Variation of household H"
CV(H)       "Compensating Variation of household H"
TEV         "Economy wide EV"
TCV         "Economy wide CV"
CV(H)=  EHREP(H,'SHOCKED')-(CPIHREP(H,'SHOCKED')/
        CPIHREP(H,'BASE'))*EHREP(H,'BASE');
EV(H) = (CPIHREP(H,'BASE')/CPIHREP(H,'SHOCKED'))
        *EHREP(H,'SHOCKED') -EHREP(H,'BASE');
TEV= 100*(sum(H,EV(H))/sum(H,EHREP(H,'BASE')));
TCV= 100*(sum(H,CV(H))/sum(H,EHREP(H,'BASE')));
DISPLAY EV,CV, TEV, TCV;
```

Appendix 5

Disaggregate Social Accounting Matrix 2000 for Saudi Arabia, (SR million)

		1	2	3	4	5	6	7	8
		A-AGRI	A-CRDO	A-REFI	A-MANF	A-UTIL	A-CONS	A-TRDS	A-NTRDS
1	A-AGRI	0	0	0	0	0	0	0	0
2	A-CRDO	0	0	0	0	0	0	0	0
3	A-REFI	0	0	0	0	0	0	0	0
4	A-MANF	0	0	0	0	0	0	0	0
5	A-UTIL	0	0	0	0	0	0	0	0
6	A-CONS	0	0	0	0	0	0	0	0
7	A-TRDS	0	0	0	0	0	0	0	0
8	A-TRDS	0	0	0	0	0	0	0	0
9	C-AGRI	4646	102	66	19038	0	989	1432	595
10	C-CRDO	55	1626	24389	12010	1462	1978	1555	53
11	C-REFI	1955	6905	3023	24670	280	27587	30672	11748
12	C-MANF	451	4590	329	9280	971	4615	6682	420
13	C-UTIL	3	6	3	19	2	7	47	8
14	C-CONS	374	1220	280	7609	134	10100	15329	4202
15	C-TRDS	5430	5431	4495	22429	931	20075	59205	7259
16	C-NTRDS	178	448	307	2668	60	574	5453	1076
17	SLAB	4049	6076	1133	5454	1453	1603	57720	22995
18	NSLAB	0	0	0	0	0	0	0	0
19	CAP	0	0	0	0	0	0	0	0
20	ACTAX	0	0	0	0	0	0	0	0
21	SHH	0	0	0	0	0	0	0	0
22	NSHH	0	0	0	0	0	0	0	0
23	INDTAX	0	0	0	0	0	0	0	0
24	GOV	0	0	0	0	0	0	0	0
25	S-I	0	0	0	0	0	0	0	0
26	ROW	0	0	0	0	0	0	0	0
27	IMPTAX	0	0	0	0	0	0	0	0
	TOTAL	48970	280231	53975	163243	8978	92424	340508	96109

Disaggregate Social Accounting Matrix 2000 for Saudi Arabia, (SR million)..Continue

		9	10	11	12	13	14	15	16
		C-AGRI	C-CRDO	C-REFI	C-MANF	C-UTIL	C-CONS	C-TRDS	C-NTRDS
1	A-AGRI	48970	0	0	0	0	0	0	0
2	A-CRDO	0	280231	0	0	0	0	0	0
3	A-REFI	0	0	53975	0	0	0	0	0
4	A-MANF	0	0	0	163243	0	0	0	0
5	A-UTIL	0	0	0	0	8978	0	0	0
6	A-CONS	0	0	0	0		92424	0	0
7	A-TRDS	0	0	0	0	0	0	340508	0
8	A-NTRDS	0	0	0	0	0	0	0	96109
9	C-AGRI	0	0	0	0	0	0	0	0
10	C-CRDO	0	0	0	0	0	0	0	0
11	C-REFI	0	0	0	0	0	0	0	0
12	C-MANF	0	0	0	0	0	0	0	0
13	C-UTIL	0	0	0	0	0	0	0	0
14	C-CONS	0	0	0	0	0	0	0	0
15	C-TRDS	0	0	0	0	0	0	0	0
16	C-NTRDS	0	0	0	0	0	0	0	0
17	SLAB	0	0	0	0	0	0	0	0
18	NSLAB	0	0	0	0	0	0	0	0
19	CAP	0	0	0	0	0	0	0	0
20	ACTAX	0	0	0	0	0	0	0	0
21	SHHN	0	0	0	0	0	0	0	0
22	SHH	0	0	0	0	0	0	0	0
23	INDTAX	0	0	0	0	0	0	0	0
24	GOV	0	0	0	0	0	0	0	0
25	S-I	0	0	0	0	0	0	0	0
26	ROW	5980	0	201	107058	1	2686	44709	0
27	IMPTAX	510	0	17	9123	0	0	0	0
	TOTAL	55460	280231	54193	279424	8979	95110	385217	96109

Disaggregate Social Accounting Matrix 2000, (SR million).. Cont.

		17	18	19	20	21	22	23	24
		SLAB	NSLAB	CAP	ACTAX	SHH	NSHH	INDTAX	GOV
1	A-AGRI	0	0	0	0	0	0	0	0
2	A-CRDO	0	0	0	0	0	0	0	0
3	A-REFI	0	0	0	0	0	0	0	0
4	A-MANF	0	0	0	0	0	0	0	0
5	A-UTIL	0	0	0	0	0	0	0	0
6	A-CONS	0	0	0	0	0	0	0	0
7	A-TRDS	0	0	0	0	0	0	0	0
8	A-NTRDS	0	0	0	0	0	0	0	0
9	C-AGRI	0	0	0	0	6984	31142	0	1527
10	C-CRDO	0	0	0	0	199	890	0	72
11	C-REFI	0	0	0	0	21772	97087	0	678
12	C-MANF	0	0	0	0	1206	5376	0	0
13	C-UTIL	0	0	0	0	615	4163	0	4106
14	C-CONS	0	0	0	0	69	309	0	
15	C-TRDS	0	0	0	0	36329	110287	0	106762
16	C-NTRDS	0	0	0	0	2689	11996	0	70660
17	SLAB	0	0	0	0	0	0	0	0
18	NSLAB	0	0	0	0	0	0	0	0
19	CAP	0	0	0	0	0	0	0	0
20	ACTAX	0	0	0	0	0	0	0	0
21	SHH		108962	0	0	0	0	0	23126
22	NSHH	100483	0	236843	0	0	104411	0	288841
23	INDTAX	0	0	0	0	0	235684	0	0
24	GOV	0	0	245883	12731	0	0	235684	0
25	S-I	0	0	0	0	4518	86418	0	-37851
26	ROW	0	0	0	0	57707	79543	0	46027
27	IMPTAX	0	0	0	0	0	0	0	0
	TOTAL	100483	108962	482726	12731	132088	767306	235684	503948

Continue ..

Disaggregate Social Accounting Matrix 2000, (SR million)

		25	26	27	
		S-I	ROW	IMPTAX	TOTAL
1	A-AGRI	0	0	0	48970
2	A-CRDO	0	0	0	280231
3	A-REFI	0	0	0	53975
4	A-MANF	0	0	0	163243
5	A-UTIL	0	0	0	8978
6	A-CONS	0	0	0	92424
7	A-TRDS	0	0	0	340508
8	A-NTRDS	0	0	0	96109
9	C-AGRI	-11313	252	0	55460
10	C-CRDO	3731	232211	0	280231
11	C-REFI	-13263	24553	0	279424
12	C-MANF	28494	33536	0	54193
13	C-UTIL	0	0	0	8979
14	C-CONS	55081	403	0	95110
15	C-TRDS	0	6584	0	385217
16	C-NTRDS	0	0	0	96109
17	SLAB	0	0	0	100483
18	NSLAB	0	0	0	108962
19	CAP	0	0	0	482726
20	ACTAX	0	0	0	12731
21	SHH	0	0	0	132088
22	NSHH	0	36728	0	767306
23	INDTAX	0	0	0	235684
24	GOV	0	0	9650	503948
25	S-I	0	9645	0	123324
26	ROW	0	0	0	343912
27	IMPTAX	0	0	0	9650
	TOTAL	62730	343912	9650	

Reference

Abeysinghe, Tilka (2001),”Estimation of direct and indirect impact of oil on growth”, *Economic letters (73), 147-153.*

Abu-Dahesh, Abdulwahab (1998),"The Impact of Foreign Trade policies on the Saudi Arabian Economy: A Dynamic Computable General Equilibrium Analysis", *Unpublished Dissertation, American University, Washington, D.C. 20016.*

Accounting Matrix: Methodological Concerns and Empirical Issues", *9th National Convention on Statistics (NCS)EDSA Shangri-La Hotel, October 4-5.*

Acharya, Sanjaya and Cohenb, Solomon (2008),"Trade liberalization and household welfare in Nepal", *Journal of Policy Modeling 30, 1057–1060.*

Adelman and Robinson, (1988),”Macroeconomic Adjustment and Income Distribution, Alternative Model Applied to Two Economies”, Journal of development Economics, 29, pp.23-44.

Adkins, Liwayway and Garbaccio , Richard (1999), "A Bibliography of CGE Models Applied to Environmental Issues", *U.S. Environmental Protection Agency, Office of Policy, Office of Economy and Environment.*

Al-Aali, Abdulrahman (1997),"Saudi non-oil export: The challenges and Prospect", Presented at the *Annual Meeting of middle East Studies association of North America (MESA), 22-25 Novemeber, 1997, sanfranscisco, CA,USA. , King Saud University, Riyadh, Saudi Arabia.*

Alhajji, A.F., Huettner, D., (2000),” OPEC and world crude oil markets from 1973 to 1994: cartel, oligopoly or competitive?” *Energy Journal, (21), 31-60.*

Al-Hassoon, Ibrahim (2005),"Estimating the Relationship Between GDP Growth and Government spending in Four GCC Countries: A Comparison of GDP and Non-Oil GDP Growth", *Unpublished Dissertation, Department of Economics, Colorado University, Fort Collins, Colorado.*

Al-Otaibi, Mohamed (2006),"Economic Study of Relationship between Privatization and Economic Growth from a Sample of Developing Countries", *Unpublished Dissertation, Department of Economics, Colorado State University, Fort Collins, Colorado*.

Al-Qudair, Khalid (2003), "The Relationship between Government Expenditure and Revenues in the Kingdom of Saudi Arabia:Testing for Cointegration and Causality", Associate Professor, *Department of Economics, College of Administrative Sciences, King Saud University, Riyadh, Saudi Arabia.*

Al-Sahlawi, Masudul et al (2000),"Oil and non-oil sector in the Saudi Arabia economy", *Organization of the Petroleum Exporting Countries (OPEC).*

Al-Thumairi (2006), "Fiscal Policy reform in Saudi Arabia: Results from a dynamic General Equilibrium Analysis", *Department of Economic, University of King Saud, Riyadh, KSA.*

Al-Thumairi, Imtithal (2006),"Fiscal Policy Reform in Saudi Arabia: Results from a Dynamic General equilibrium Analysis", *University of King Saud, Department of Economics.*

Anderson, James and Neary, Peter (2006), "Welfare versus market access: The implications of tariff structure for tariff reform", *Department of Economics, Boston College, Chestnut Hill, MA 02167-3806, USA .,b NBER, c UCD School of Economics, University College Dublin, Belfield, Dublin 4, Ireland d CEP.*

Armington, Paul S.(1969),"A Theory of Demand for Products Distinguished by Place Production", *IMF Staff Papers, v 16, pp.159-176.*

Baulino, Amelia and Thirwall, A.(2004),"The Impact of Trade liberalization on Exports, Imports and The Balance of Payments of Developing Countries", *The Economic Journal, 114 (February), F50-F72.*

Benjamin et al. (1989),"The Dutch Disease in a development Country oil Reserve in Cameron", *Journal of development economics, 30, pp.71-92.*

Bergman, Lars (1983), "A System of Computable General Equilibrium Models for A Small Open Economy", *Mathematical Modeling, VoL 3, pp. 421-435, 198.*

Bergman, Lars and Henderson, Magnus (2003) "CGE Modelling of Environmental Policy and Resource Management", *Stockholm School of Economics, Department of Economics Box 6501 (Sveavaegen 65).*

Bergman, Lars. 1988. Energy Policy Modeling: A Survey of General Equilibrium Approaches. *Journal of Policy Modeling*, 10:3, pp. 377-99.

Berument, Hacan and Cylan, Nildag (2005), "The Impact of Oil Price Shocks on The Economic Growth of the Selected MENA Countries ", *Department of Economics, Belkant University, Ankara, Turkey; Department of Management, Atlima University.*

Bhanumurthy, K.V.(2002),"Arguing a Case for the Cobb-Douglas Production Function", *Department of Commerce, University of Delhi, Delhi School of Economics, Delhi.*

Bhattacharyya, Subhe (1996),"Applied General Equilibrium models for Energy Studies: A Survey ", *Energy Economics 18, p.145-164*.

Braber M. C. et al. (1996),"Policy Modeling Under Fixed and Flixible Price Regions: SAM-CGE Transitional Applications to Poland and Hungary", *Journal of Policy Modeling, 18 (5): 495-529.*

Briones et al. (2006),"A Regional CGE Model with Distributional Analysis for the Philippines: The Geographic Dimension of Welfare Impact", *Final version for presentation to the 5 PEP Conference, United Nations Conference Center, Addis Ababa, Ethiopia, 18-22 June 200.*

Brooke, A., D. Kendrick and A. Meeraus (1988), GAMS. A User´s Guide. Redwood City.

Cardenete, M.A. and F. Sancho, (2003), "An Applied General Equilibrium Model to Assess the Impact of National Tax Changes on a Regional Economy," Review of Urban and Regional Development Studies 15(1), 55-65.

Carneiro, Francisco and Arbache , Jorge Saba (2008),"The Impacts of Trade on the Brazilian LaborMarket: A CGE Model Approach", *World Development Vol. 31, No. 9, pp. 1581–1595, 2003.*

Chang, Youngho and Wang, Fong (2003),"Oil price fluctuations and Singapor economy", *Energy Policy 31, pp. (1151–1165).*

Chemingui, Abdelbasset and Lofgren, Hans, (2004), “Tax Policy Reform in Saudi Arabia: A gene ral Equilibrium Analysis”, *Research Scientist at Kuwait Institute for Scientific Research and economic research, World Bank.*

Cheminqui, Mohamed (2000),”Tax reform policy in Saudi Arabia: Computable general equilibrium), *Kuwait institute for scientific research and economic research forum.*

Chenery, Hollis and William Raduchel,(1971),"Substitition in Planning Models", *in Hollis Chenery (ed), Studies in Development Planning. Cambridge, Massachusetts: Harvard University Press, pp. 29-47.*

Chulu, Osten and Wobst, Peter (2001), “A 1998 Social Accounting Matrix for Malawi”, *Agricultural Policy Research Unit, Bunda College of Agriculture. , International Food Policy Research Institute, 2033 K Street, N.W., Washington, D.C. 20006, U.S.*

Chung-ILi, Jennifer (2002), “A 1998 Social Accounting Matrix (SAM) for Thailand”, *University of North Carolina at Chapel Hill, International Food Policy Research Institute Trade and Macroeconomics Division, International Food Policy Research Institute 2033 K Street, N.W., Washington, D.C. 20006, U.S.A.*

Coffman (2008), “Oil price shocks in an island economy: an analysis of the oil price-macroeconomy relationship”, *Department of Urban and Regional Planning, University of Hawaii at Manoa, Honolulu..*

Coffman, Makena (2008), "Oil price shocks in an island economy: an analysis of the oil price-macroeconomy relationship", *Department of Urban and Regional Planning, University of Hawaii at Manoa, Saunders Hall 107D, 2424 Maile Way, Honolulu, HI 96822, USA.*

Cooper, John (2003),"Price elasticity of demand for crude oil: estimate for 23 countries", OPEC.

Cororaton, Caesar (2003), "Analyzing the Impact of Trade Reforms on Welfare and Income Distribution Using CGE Framework: The Case of the Philippines", *Philippine Institute for Development Studies, Discussion paper NO. 2003-01.*

Damuri and Perdana (2003), "The Impact of Fiscal Policy on Income Distribution and Poverty: A Computable General Equilibrium Approach for Indonesia", *Economics Working Paper Series (CSIS).*

De Miguel, Carlos et al (2003),"Oil price shocks and aggregate fluctuations", *The Energy Journal; 2003; 24, 2; Research Library pg. 47.*

De Santis, Robert A., "Crude oil price fluctuations and Saudi Arabia's behaviour", *Energy Economics, 25, pp.155-173.*

De Santis, Roberto (2003)," Crude Oil Price Fluctuations and Saudi Arabian behaviors", *Energy economics, 25, pp.155-173.*

Decaluwe, Bernard (1988),"A concise empirical survey of 73 applications to 26 countries", *Journal of Policy Modelling, 10(4):529-568*.

Dees, Stepheane. et al.(2007)"Modelling the world oil market: Assessment of a quarterly econometric model", Energy policy, (35), pp.178-191.

Defourny, Jacques and Thorbecke, Erik (1984), " Structural Path analysis and Multiplier Decomposition Within a Social Accounting Matrix Framework", *The Economic Journal*, 94, 111-136.

Dervis, de J. and Robinson, S. (1982) "General Equilibrium Models for Development policy", Cambridge: Cambridge University Press.

Descamps, Patricia et al. (2005)," Macroeconomic Shocks, Poverty and Income Distribution in Venezuela", *Patricia Descamps is a Junior Financial Analyst at Procter & Gamble. Federico Ortega and Germán Ríos are respectively Economist and Principal Economist at the Andean Development Bank.*

Devarajan, S. (1988), “Natural Resources and Taxation in Computable General Equilibrium Models of Developing Countries”, *Journal of Policy Modeling*, 10(4), 505-528.

Dixon, P. B., Parmenter, B. R., Powell, A. A. and Wlcoxen, P. J. (1992)," Notes and problems in applied general equilibrium economics", *North-holland, Amsterdam.*

Dixon, Peter (2006)," Evidence-based Trade Policy Decision Making in Australia and the Development of Computable General Equilibrium Modeling", *Centre of Policy Studies, Monash University, Australia*.

Dominguesa, Edson et al. (2008), "Sensitivity analysis in applied general equilibrium models: An empirical assessment for MERCOSUR free trade areas agreements", *The Quarterly Review of Economics and Finance*, 48, p. 287–306

Dornbush, Rudiger (1992),"The Case for Trade Liberalization in Developing Countries", Journal of Economic Perspectives, 6, (1), pp.69-85.

Doroodian and Boyd (2003),“The linkage between oil price shocks and economic growth with inflation in the presence of technological advances: a CGE model “, *Energy of Policy, 31, 989-1006.ok.*

Doroodian et tal. (1994),"An Examination of the Traditional Aggregate Import Demand Function for Saudi Arabia", *Applied Economics, 1994, 26, pp. 909-915.*

Energy Information Agency, (EIA , 2010).

Farmer, Karl and Wendner, Ronald, (2001),”Dynamic Multi-Sector CGE Modeling and the Specification of Capital”, *Department of Economics, Graz University, Austria.*

Feraboli and Trimbron (2008), “Trade Liberalization and Income Distribution: A CGE Model for Jordan”, *Business Administration, Chemnits University of technology, Germany and Department of economics, Institution of Macroeconomics, University of Hannover, Hannover, Germany.*

Fredriksen, Katharine (2006),” China’s Role in the world: Is china a responsible stakeholder?” office of policy and international affairs, united state Department of energy.

Ghosh, Sajal (2009), “Import demand of crude oil and economic growth: Evidence from India”, *Energy Policy 37, pp. 699 –702.*

Go, Deb S.(1994),"External shocks, adjustment policies and investment in a developing economy: Illustrations from a forward-looking CGE model of the Philippines", *Journal of Development Economics 44 (1994) 229-261.*

Goce-Dakila , Cristela and Dakila Jr., Francisco G.(2004), "Construction of Regional Social Accounting Matrix:Methodological Concerns and Empirical Issues", 9th National Convention on Statistics (NCS)EDSA Shangri-La Hotel, October 4-5.

Habeeb, Salah (1991),“A diversification policy model for the Saudi Arabian economy (CGE model)”, *Unpublished Dissertation, State University of Oklahoma.*

Haji, J.A (1993), “The construction of the Social Accounting Matrix (SAM) for Saudi Arabia.”, *Margin, April issue.*

Hamilton, James D. (2009),”Causes and consequences of the oil shock of 2007-08”,

Heiat, Nafisseh (1988),"A Supply-Demand model for OPEC Oil policies", *Portland State University, USA.*

Henderson, Simon (2008)," OPEC Deliberates: A Saudi Opportunity", *the Washington Institute. Policy Watch #1416.*

Hnyiliczy and Pindyck (1976), “Pricing Policies for a Two-Part Exhaustible Resource Cartel: The Case of OPEC ”, Massachusetts Institute of Technology Cambridge, Massachusetts U.S.A.

Hogan.H.H, (1992),”OECD oil demand dynamics: trend and symmetries “, *International Energy Agency, Annual Statistical Supplement for 2000, Paris.*

IMF, Staff papers,(2006),”Oil price movements and the global economy”, vol.55, No. 2

Iqbal, Zafar and Siddiqui, Rizwana (2001), "Critical Review of Literature on Computable General Equilibrium Models", *Pakistan Institution and Development Economics..*

Johansen, Leif (1960), “A Multi-Sectoral Study of Economic Growth”, *North Holland Publishing Company Amsterdam. (Text book).*

Johansen, Leif (1961), “A Multi-Sectoral Study of Economic Growth”, *The American economic Review, 51, (3). pp. 436-438.*

Johns, Keithly (2006),"Effects of Relative Prices and Exchange Rates on Domestic Market Share of U.S.Red-Meat Utilization", *an Agricultural Economist with the Animal Products Branch, Markets and Trade Economics Division, Economic Research Service, USDA. Contact authors at 1800 M,Street NW, Washington DC*

Karingi and Siriwardana (2001) “Structural Adjustment policies and the Kenyan economy: A Computable General Equilibrium Model Analysis.”, *African Development Bank, Published by Blackwell publishers, 108 Cowley Road,Oxford OX4 1JF,UK.*

Karingi and Siriwardana (2001), “Structural adjustment policies and the Kenyan Economy: A computable General Equilibrium model Analysis”, *African development Bank, Published by Blackwell publisher, Oxford, UK. Kenya.*

Kilian, Lutz (2007),""Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocksin the Crude Oil Market", *University of Michigan and CEPR*

Kilian, Lutz (2008),"The Economic Effects of Energy Price Shocks", *University of Michigan and CEPR.*

Konan, Denise and Maskus, Keith (2000), "Joint trade liberalization and tax reform in a small open economy: the case of Egypt", *Journal of Development EconomicsVol. 61 _2000. 365–392.*

Krichene, Noureddine (2002),”World crude and natural gas: a demand and supply model”, *International monetary fund (IMF).*

Krugman, Paul; Obstfeld, Maurice and Wesley, Addison (2008)" *International Economics, Book,Publisher: Pearson Education Limited, Publish. Date: 3rd July 2008*.

Lee Harris, Rebecca (2002), “Estimation of a regionalized Mexican social accounting matrix: Using entropy techniques to reconcile disparate data sources”, *Globalization Research Center, University of South Florida , Trade and Macroeconomics Division, International Food Policy Research Institute, 2033 K Street, N.W., Washington, D.C. 20006, U.S.A.*

Legrain, Philippe (2006), "Why NAMA Liberalisation is Goodfor Developing Countries", *The World Economy.*

Liew, Chong and Liew, Chung (1988),"Measuring the Effect of Cost Variation on Indusrial Output *“Journal of Regional Science, Vol.28, NO.4.*

Lofgren et al. (2002), "A Standard Computable General Equilibrium (CGE) Model in GAMS", *International Food Policy Research Institution.*

Looney, Robert (1990),"Economic Development in Saudi Arabia: Consequences of the Oil Price Decline". *Greenwich, Connection: JAI Press Inc.*

Luo, Y. Y. (2007),” Researches on consumption–investment relations”, .*Beijing: China Planning Press. (in Chinese).*

Melo, Jaime de (1988),"Commutable General Equilibrium Models for Trade Policy Analysis in Developing Countries: A Survey", *Journal of Policy Modeling, 10(4): 469-503.*

Michaely et al (1991),"Liberalizing foreign Trade, Vol.7 Lessons of experience in the developing world", *Oxford and Cambridge, MA: Basil Blackwell.*

Miguel et al. (2003), “Oil price Shocks and Aggregate fluctuations”, *The Energy Journal, 24, 2, research library..*

Ministry of Planning and Economic, Five Development Plan (1970-2009).

Naqvi, Farzana (1989). "A computable general equilibrium model of energy, economy and equity interactions in Pakistan" *Energy Economics 20, P. 347-373*

Nenci Silvia and Pietrobelli, Carlo (2007),"Does Tariff Liberalization Promote Trade? Latin America long-run (1900-2000)", *University of Rome La Sapienza , Crei,* *university of Rome 3.*

NT

Nyamadzabo, Taufila (2003)," The Static and Dynamic Welfare Effects of Botswana's Participation in Southern Africa Regional and Multilateral Trade Integration.

OPEC, (2006), "Oil Outlook to 2025", OPEC Secretariat.

OPEC, Organization of the Petroleum Exporting Countries, (2007), "Impact of higher oil prices, on the Chinese economy".

Pereira, Alfred0 M. and Shoven, John B. (1988),"Survey of Dynamic Computational General Equilibrium Models for Tax Policy Evaluation", *Journal of PO/ICY Modeling 10(3):401-436 (1988).*

Pirog, Robert (2005)," World Oil Demand and its Effect on Oil Prices", *Specialist in Energy Economics and Policy Resources, Science, and Industry Division Supply Shocks in the Crude Oil Market, University of Michigan., Unpublished Assessed Article, Bradford University, Bradford, USA.*

Pradhan, Basanta and Sahoo, Amarendra (2000)," Oil Price Shocks and Poverty in a CGE Framework", *National Council of Applied Economic Research, 11 - I.P. Estate, New Delhi - 110 002.*

Progress-A Computatable General Equilibrium Analysis", Dissertation, Faculty of College of Arts and Sciences of American University, United States.

Pyatt G. and Thorbecke, E. (1976)," Planning Techniques for a Better Future", Geneva, ILO.

Pyatt, G. (1999)," Some relationships between T-accounts, input-output tables and social accounting matrices", *Economic Systems Research, 11(4), 365-387.*

Pyatt, G. and J.I. Round (1985), "Social Accounting Matrices: A Basis for Planning", *A World Bank Symposium, World Bank*.

Pyatt, Graham (1988),"Approach to Modeling", *Journal of P&cy Modeling 10(3):327-*

352.

Robinson, S. (1991)," Macroeconomics, Financial Variables, and Computable General Equilibrium Models", *World Development 19: 11 P.1509-1525.*

Robinson,Sheman et al (2001),"Updating and Estimating a Social Accounting Matrix Using Cross Entropy Methods", *Economic Systems Research, Vol. 13, No.1*.

Roland, Host et al. (1990),"Interindustry analysis with social accounting methods", *Economic Systems Research, Vol. 2, Issue .2.*

Round, Jeffery I. (2003),"Constructing SAMs for Development Policy Analysis: Lessons Learned and Challenges Ahead", *Economic Systems Research*..

Saudi Araabia Fact Book, Gateway to the Kingdom, NCP Capital Research Department, 2009

Saudi Arabia Monetary Agency (SAMA),

Sen, A. (1963),"Neo-Classical and Neo-Keyneian tTheories of Distribution", *Economic Record, PP.53-64.*

Sen, H. (1996), "Social Accounting Matrix and its Implications for macroeconomic Planning", *Unpublished Assessed Article, Bradford University, Bradford, USA. Vol. 15, No. 2, June 2003*.

Shoven and Whalley (1984), "Applied General Equilibrium Models of Taxation and International Trade: An introduction and survey" *Journal of Economic Literature, 22, 3, pp.1007-1051.*

Shoven and Whalley, (1992)," Appling General Equilibrium", Cambridge University Press.social accounting matrices", *Economic Systems Research, 11(4), 365-387.*

Song, Z. (1999),"Analysis of Chinese saving behavior", *Journal of Finance, 6, 46–51. (in Chinese).*

Taylor, L and Lysy, F. (1979),"Vanishing Income Distrib ution: Keynsian clues about

Model –Surprice in the Short-Run " *Journal of Development Economics 6 p.11-29 The Case of OPEC" , European Economic Review, 8, p.(139-154.*

Thiele, Rainer and Piazolo, Daniel (2003),"A Social Account Matrix for Bolivia Featuring Formal and Informal activities", *Cuadernos de Economía, Año 40, Nº 120, pp. 285-318 (Agosto 2003).*

Thissen, Mark (1998),"Two decades of CGE modeling Lessons from Models for Egypt", *SOM Research Report 99C02, University of Gronongen, Groningen, The Netherlands, Decemeber.*

Thurlow, James (2004),"A dynamic Computable General Equilibrium (CGE) Model for South Africa: Extending the Static IFPRI Model", *International Food Policy research Institute, Washington, D.C.*

Wan, G. H., Zhang, Y., & Niu, J. G. (2001)," Liquidity constraints, uncertainty and household consumption in China", Economic *Research Journal, 11, 35–45. (in Chinese).*

Wu, Y. F., & Qian, M. Z. (2004), An empirical analysis on the factors that affecting the consumption demand. Economic Theory and Business Management, 2, 13–16. (in Chinese).

Xu, Guangiian et. Al (2010)," Why Has China's Final Consumption Rate Declined Since 1978? Causes and Implications", *Journal of Family and Economic Issues, v. 31,iss. 3, p.338-352.*

Xu, Y. B. (2005). Further study about the causes of decline of domestic consumption. Finance and Trade Economics, 12, 51–54. (in Chinese).

Yang, Chin-Wen et al. (2006)," Assessing the Effect of Oil Price Shock Using an Energy-Economy Decision Model with Technology Characteristics", *Proceedings of the 9th Joint Conference on Information Sciences, JCIS 2006, art. No.CIEF-228.*

Zang, X. H., & Pei, C. X. (2004),"Econometric analysis of the precautionary savings, liquidity constraints and household consumption in China", *Economic Perspectives, 12, 28–31.(in Chinese).*

Zaouali, Sana (2007), "Impact of higher oil price on the Chinese economy", OPEC.

Zheng, X. L. (2007),” Improving household consumption rate is an important task of micro-control”, *Macroeconomic Management, 9, 16–17. (in Chinese).*

Websites:

EIA-Global Oil Consumption

http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/oil_market_basics/demand_text.htm#Measuring%20Oil%20Consumption

Mark pery (2008) "Oil Prices Rose Due To Supply And Demand"

http://www.dailymarkets.com/economy/2008/07/27/cftc-oil-prices-rose-due-to-supply-and-demand/

IMF(2000), The Impact of Higher Oil Prices on the Global Economy

http://www.imf.org/external/pubs/ft/oil/2000/oilrep.PDF

http://implan.com/v3/

"Elements of the Social Accounting Matrix", Minnesota IMPLAN Group, Inc., MIG IMPLAN Technical Report TR-98002.

http://www.cdsi.gov.sa/showcatalog.aspx?lid=26&cgid=1022

Central department of statistics and information link

https://www.cia.gov/library/publications/the-world-factbook/geos/sa.html

C.I.A Fact book, accessed link

http://www.ameinfo.com/110097.html

The Ultimate Middle East Business Resource

Monfort(2008)

http://www.worldwatch.org/node/5666#notes

http://archive.arabnews.com/?page=6&section=0&article=74580&d=12&m=12&y=2005